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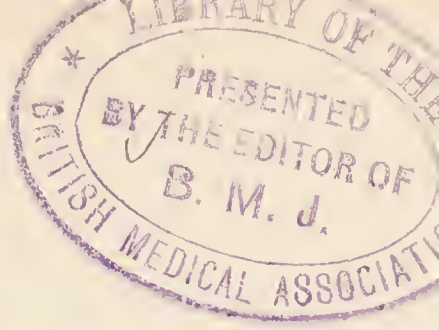
SURGERY
OF THE
SPINE AND EXTREMITIES

TAYLOR

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SURGERY
OF THE
SPINE AND EXTREMITIES

A TEXT BOOK FOR STUDENTS AND PRACTITIONERS

BY

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WITH 604 ILLUSTRATIONS

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PREFACE

Knowledge in regard to Bone and Joint Surgery has increased much of late, incident to the Great War, and its importance in relation to General Surgery is recognized. These advances should be known by the general practitioner as well as the student. Such subjects are Bone Grafting for delayed union in fracture, fixation of infected joints and correction of congenital deformities; Tendon Transplantation and other operative measures for the relief of paralytic deformities, enabling the sufferer to discard braces and aiding in many instances the restoration of function; newer conceptions in regard to the treatment of Bone Tuberculosis; advanced ideas upon the etiology and treatment of Infectious Arthritis and other internal derangements of joints and their periarticular coverings.

These and many other conditions described in detail show what modern surgery may accomplish and are of great value to the practitioner. Much space is given up in the present volume to original studies and methods in Osteoclasis, Tendon Transplantation, Anthropometry, Pott's Disease, Scoliosis, Posture, Club Foot and Flat Foot, Mobilization of Joints, Treatment of Sinuses and other subjects, which have been found useful to the author and in many instances hitherto unpublished.

No attempt has been made to make the work encyclopedic, but an endeavor has been made to put in the hands of the reader a brief and useful text book.

Part I contains what may be called "Orthopaedic Technique," a subject of great importance to medical attendants and one wholly neglected, as a rule, in text books and in the training of students and nurses. These details mean much to the comfort of the patient and have important bearing on the end-result in many cases. With the changes incident to the more or less transient personnel in a hospital, of both internes and nurses and for post-graduate students, the author has found it wise to place the information and data herein contained in their hands. For new incumbents in hospitals it insures team-work, good technique and the desired service.

In Parts II and III, the spine and extremities are taken up and an endeavor has been made to base the treatment upon advanced pathology and sound diagnosis. Part II is an amplification of the author's book on The Spine, which was printed privately some years ago for his students. In the majority of instances, methods are stressed chiefly, which have proven beneficial to the patient and of value to the author. Obsolete and earlier cumbersome means of treatment, time wasting to the reader and in the application, are omitted.

Both in text and illustration, careful effort has been made throughout to give credit to other authors and if errors and omissions have been made, deep regret will be felt.

The writer wishes especially to thank Doctor Joseph A. Blake for help in the use of his writings and illustrations on the "Balkan Frame" and Doctor J. M. T. Finney for assistance in the article on "Spasmodic Torticollis."

Grateful acknowledgment is made also for Roentgenograms to Doctors J. F. Lutz, S. C. Bowers, Charles A. Waters, Howard E. Ashbury and Henry J. Walton; to Doctors A. Duvall Atkinson and Frank S. Lynn for photographs of unusual cases and to Doctors J. K. Young, J. F. Binnie, the late Francis F. Stewart, and "Surgery, Gynecology and Obstetrics" for the use of illustrations from their publications.

R. Tunstall Taylor.

Baltimore.

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PART I

ORTHOPAEDIC TECHNIQUE

CHAPTER I

GENERAL CONSIDERATIONS AND HISTORICAL NOTES

Definition.

Orthopaedic Surgery is that branch of the Surgical Science, which has to deal with the nature, cause, prevention and treatment of deviations from the normal in the contour or motor function of the body and extremities. Any disease, accident, or condition, which tends to impair the normal, requires the application of Orthopaedic Surgery.

Formerly, Orthopaedic Surgery was the surgery of deformities in children from its Greek derivation, ὀρθὸς, straight, and παῖς, παιδὶς, child. It is now no longer applied to children only but comprises all those cases where the bones, joints, muscles, tendons, ligaments and nerves are detrimentally affected, even without deformity, yet which may present departures from normal function or alignment as an early or late manifestation of the trouble.

Because of the frequent improper spelling "Orthopedic," many consider that it has its application solely to foot disabilities of various kinds. It, however, does *not* derive its name from the Latin Pes, Pedis, meaning the foot, from which we get such words as Pedal, but it literally covers the regions of the body "from head to foot."

Scope.

Many cases seen by the Orthopaedic Surgeon are border-line affections, requiring treatment of other specialists also; such for example are scurvy and rickets, which lead to deformity and call for advice from the medical man, the paediatrist and hygienist; Osteo-Arthritis, which not alone requires orthopaedic treatment, but may require a survey by the dental surgeon, the laryngologist, the gastro-enterologist, the gynecologist, or the urologist, to detect the source ("focal infection") from which the joint trouble has come, and have them advise treatment to remove the cause. Similarly, we have to employ or seek the counsel of the hydro-, electro- and actino-therapist, gymnast and masseur, commonly now grouped under the term physio-therapist to take care of muscular weaknesses and contractures, circulatory, nerve disturbances, et cetera. In all bone and joint cases, the X-ray is essential for a proper grasp, study and diagnosis of the exact condition present, so that the roentgenologist must be closely affiliated with the orthopaedic surgeon. Thus, in private practice, the modern "group method" for "complete survey" of a case by various specialists redounds to the best interest of the patient by an exact, early diagnosis, often in proportion to the thoroughness of the study and gives the attending physician or surgeon the feeling of having been thorough in the discharge of his duty to

his patient and often gives him a new insight into a given condition. "Two heads are better than one" and four are better than two. Consultation with colleagues and between specialists are too infrequent.

Formerly, the use of braces and splints were so general in all deformities that the "Orthopaedist" was known derisively as a "buckle- and strap-man," but with the introduction of aseptic surgery, many clever operations have been devised to overcome disability to such an extent that often braces may be discarded. This operative tendency in orthopaedic surgery puts it on a high plane, as it not only promotes the nearest approach to exact cure and the greatest comfort to the patient, but saves him from much needless and endless expense in prolonging treatment and requiring the buying of braces.

The Need of the Skilled Interne and Nurse.

Without the well trained interne and nurse in orthopaedic surgery, where minute details are essential to the technique, many an operation or mechanical procedure, neglected in what may seem a minor detail, may have an end-result of the most unfavorable character from the patient's standpoint. This reflects discreditably on the surgeon, the hospital, the internes, nurses and their training.

Historical Notes.

Orthopaedic surgery as a specialty separated from general surgery is of comparatively recent date in America, for its first chair dates from 1861, when the elder Sayre filled it at Bellevue Medical College. Now forty-five of our American medical schools announce special instruction in this branch, showing the widespread recognition of its importance and but few state board examinations omit questions on this subject.

From the earliest times, however, descriptions and methods of treatment of deformity have been found in surgical literature. (Figs. 1, 2 and 3).

Nicholas Andry of Lyons, who lived from 1658 to 1742, and became a surgeon in Paris, wrote on orthopaedic surgery and originated the name "L' Orthopédie." Many have called him the "Father of Orthopaedic Surgery," but treatises on this subject are of much earlier origin, for they have been found as far back as the writings of Hippocrates, the "Father of Medicine," who lived 460–370 B.C. and monographs show that he had some very good methods in treating deformities, considering the period in which he lived. In his article "Concerning the Articulations," he wrote of the treatment of "club-foot,"[1] to be spoken of later. He also wrote of spinal affections and "tubercle within and without the lungs." In the "Hippocratic Writings"[2] of the Greek schools of Cos and Cnidos, which probably embrace not only the work of Hippocrates himself and his pupils, but also the methods and views of his predecessors, are found accounts of the articulations, of traumatic and congenital dislocations, especially of the knee, elbow aand ankle joints, methods of reduction and of apparatus.

[1] The genuine works of Hippocrates translated from the Greek, by Francis Adams, M.D., London, 1849. Published by the Sydenham Society, vol. ii, pages 632–662.

[2] J. S. Billings, History and Literature of Surgery; Dennis, System of Surgery, vol. 1, ch. 1.

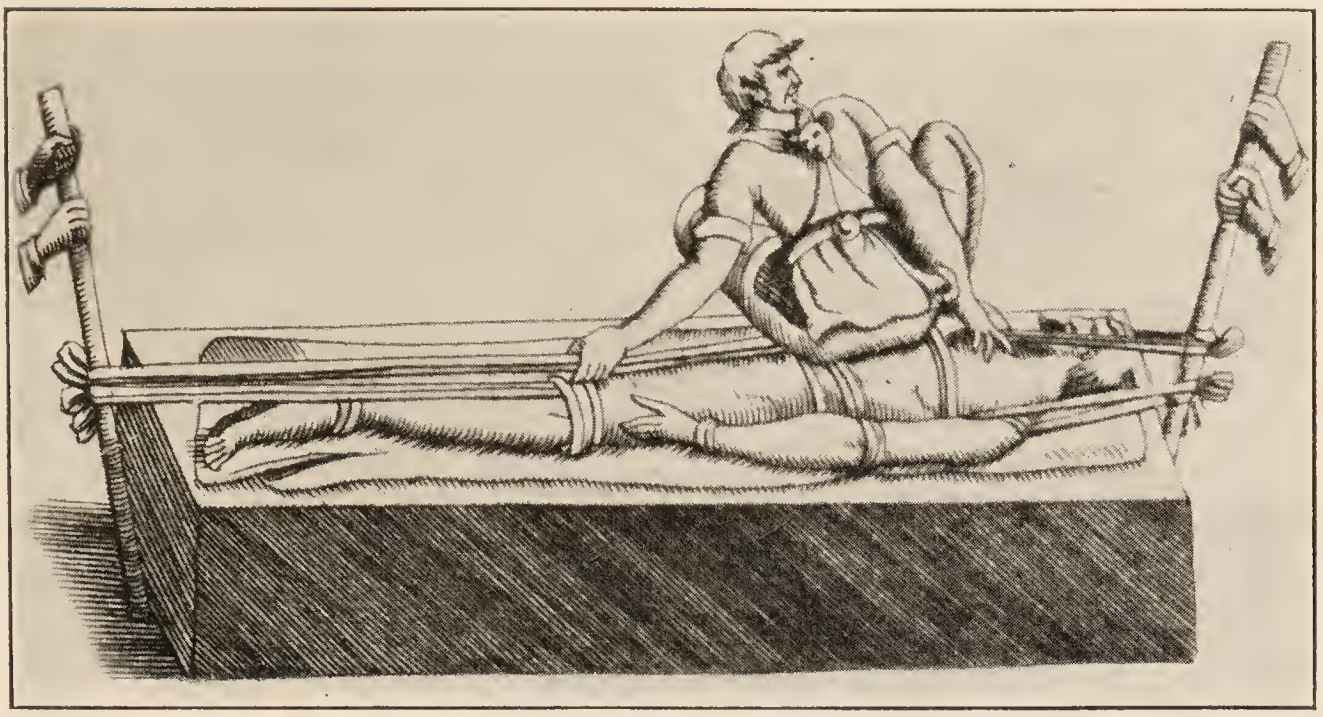


FIG. 1.

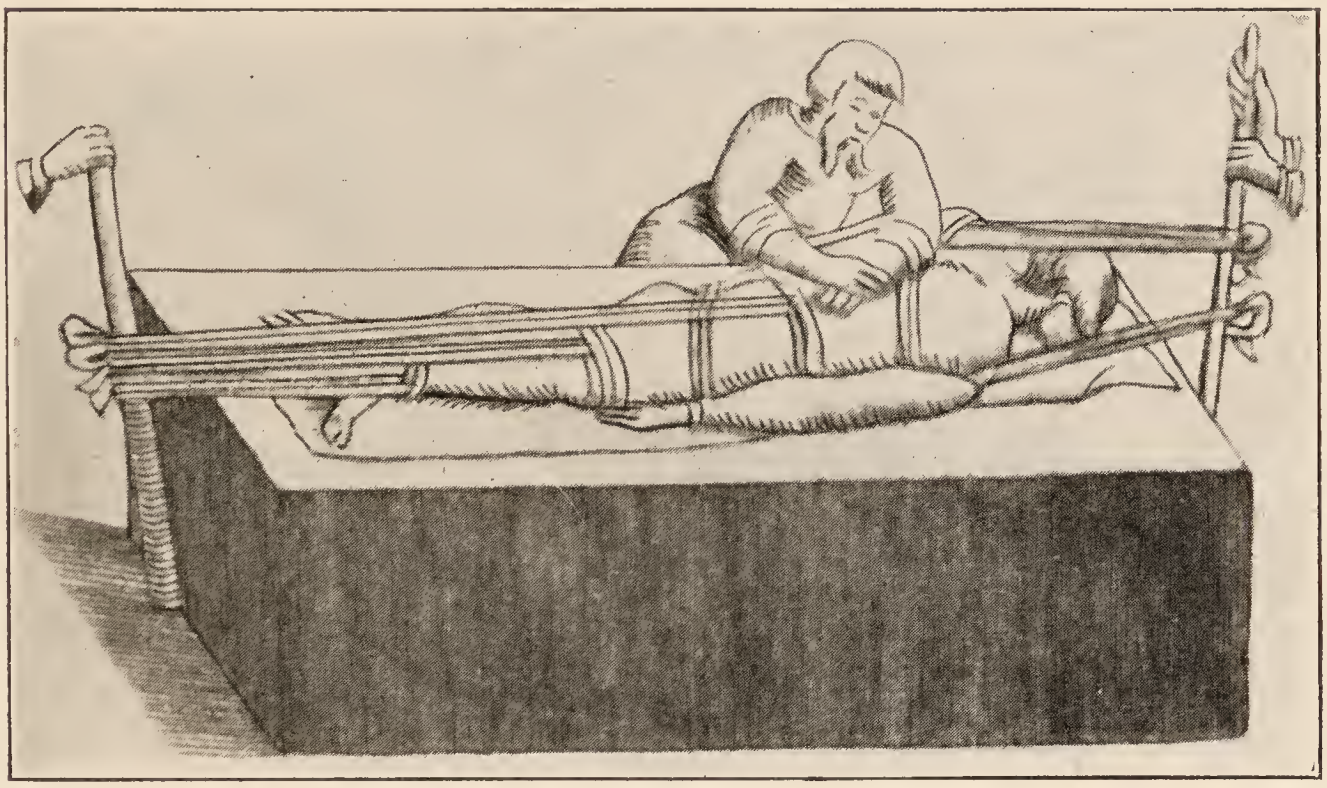


FIG. 2.



FIG. 3.

FIGS. 1—3.—Method of forcible spinal correction by the ancients. (*Young.*)

Some specimens of Jewish surgery are to be found in the Talmud, where it is shown that they knew of the application to the body of artificial parts, viz.: wooden legs and apparatus of various forms for unfortunates, who were deprived of the use of their lower extremities.

In the literature of India are found two medical works, the "Charaka" and "Susruta," the date of which compositions is variously estimated at from 1000 B.C. to 700 A.D. In the translation of "Susruta" by Anna Moreshvar Kunte, published in Bombay in 1877, we find in subdivision five, the Koumarabhrityam," which treats of the care and treatment of children and the use of appliances for them.

The first treatise on surgery was written in Rome by Aulus Cornelius Celsus, "the Medical Cicero," who lived about the beginning of the Christian era. He was more of an author of an encyclopedia or compiler of the arts and sciences for literary men, than a physician, and introduced many Greek words for which he could not find a Latin

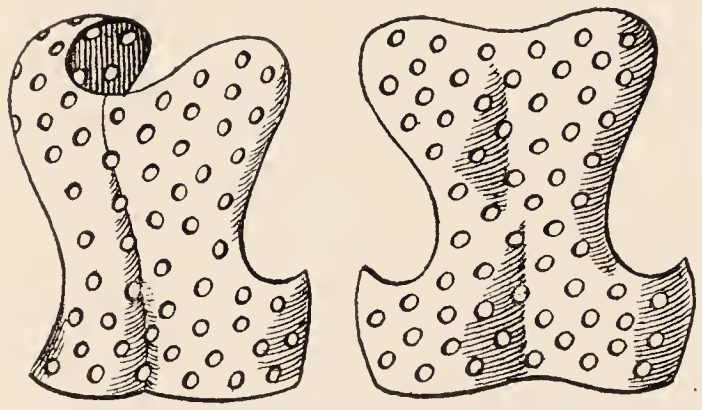


FIG. 4.—Paré's steel cuirass, 1579. (*Young.*)

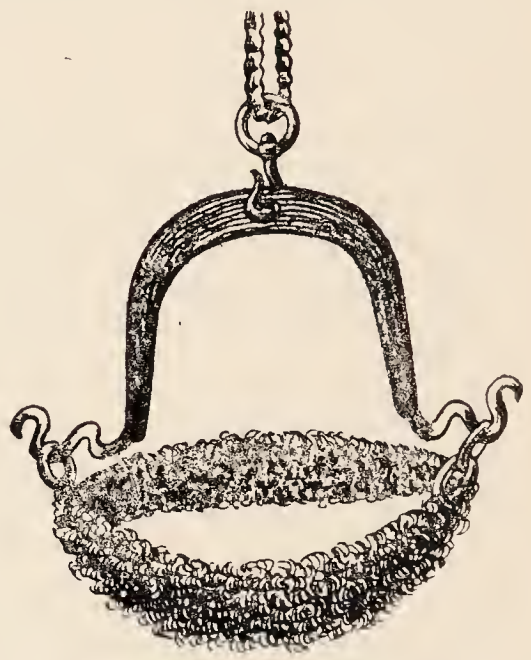


FIG. 5.—Van Nuck's suspension apparatus, 1696. (*Young.*)

equivalent. He speaks of dislocations of the head of the femur and many kinds of machines for extending the femur after reduction.

Claudius Galen, who was born at Pergamus, 131 A.D. and finally settled in Rome, is said to have written some 500 treatises on medicine. His "De usu partium" contained much anatomy and in his writings are also found a description of the section of the sterno-cleido-mastoid to correct torticollis and a method for the radical cure of hare-lip.

Aetius Amidenus of Constantinople, a Christian, who lived in the early part of the sixth century used word-charms and for removing sequestra in osteomyelitis recommends the following: "Bone, as Jesus Christ caused Lazarus to come out of the grave, as Jonah come out of the whale's belly, come out," a method which we of today find quite unavailing.

Paul of Aegina, the last of the Greek medical writers, who studied at Alexandria, lived in the early part of the seventh century and most of the Arabian physicians received their inspirations from him. He wrote seven valuable books on medicine. In fractures of the spine and spinous processes he says, "having first given warning of the danger, we must, if possible, attempt to extract by an incision the compressing bone."

Albucasis of the Arabian school, who died about 1105 A.D., wrote in his third book of fractures, luxations, sprains, etc.

Gui de Chaulic born about 1300 A.D., settled at Avignon, wrote in his "Great Surgery," as it was called, "Up to the time of Avicenna all writers were both physicians and surgeons (i.e., well educated men), but since that time, either because of fastidiousness or the excessive occupation of the clerics, surgery has become a separate branch and has fallen into the hands of the mechanics." It is to be supposed this was a slur, just as later the orthopaedic surgeons by ultra-conservatism were called "buckle- and strap-men," by their critics.



Fig. 6.—Heister's spine brace with chin piece, 1700. (*Young.*)

Ambroise Paré (1517–1590), who increased the standing of the corporation of barber surgeons although a great military surgeon and devoting so much of his time to gun-shot wounds, devised several orthopaedic methods and appliances, notably the brass cuirass for spinal disease (Fig. 4).

Paracelsus (1493–1541) contributed some little to the treatment of deformities, but his writings were chiefly given over to the care of wounds. It was he who wrote that "some surgeons use the probe merely because they have seen it used and to show that they are doing something."

Hendric Von Roonhuysen (1625–1626?), of Amsterdam, operated for hare-lip and wry-neck.

The "Leech Book," written about 970 A.D., is the oldest English medical book and in it we find, "For hare-lip pound mastic very small, add the white of an egg and mingle as thou dost vermillion, cut with a knife the false edges of the lip, sew fast with silk, then smear without and within with the salve, ere the silk rot. If it draw together, arrange it with the hand; anoint again soon."



Fig. 7.—De la Croix Skol's steel brace with jury mast, 1725. (*Young.*)

Another remarkable account of an operation in England in the seventeenth century is found in the "dairy of the Rev. John Ward, vicar of Stratford-upon-Avon" (1648–1679), in which he says: "The mountebank that cutt wry-necks cutt three tendons in one child's neck, and hee did itt thus; first by making a small orifice with his launcet, and lifting upp the tendon, for fear of the jugular veins, then by putting in his incision knife and cutting them upwards; they give a great snapp when cutt. The orifice of his wounds are small, and scarce any blood follows."

Francis Arcaeus (1493–1570?), a Spanish surgeon, described an apparatus for the treatment of club-foot and advised mercurial injunctions on the joints for syphilis, which disease had been first described by John de Vigo, an Italian surgeon, in 1514.

We now come again to Nicholas Andry (1658–1742), dean of the medical faculty of Paris in 1724, who is known in medical literature chiefly by his book, "L'Orthopédie, ou l'art de prevenir et de corriger dans les enfans les difformités

du corps" (Paris, 1741), being the first work in which the term orthopaedic is used.

Jean Louis Petit (1674–1750), of the same period, first described mollities ossium.

"The practice of medicine was forbidden to the executioners in Prussia, but in the year 1774 Frederick the Great granted to them permission to treat fractures, wounds, and ulcers and when the Berlin surgeons complained of this, he issued an order saying that he had not permitted all executioners, but only the skillful ones to practice and if the surgeons are as skillful, as they pretend to



FIG. 8.—Le Vascher's corset with jury mast, 1764. (*Young.*)

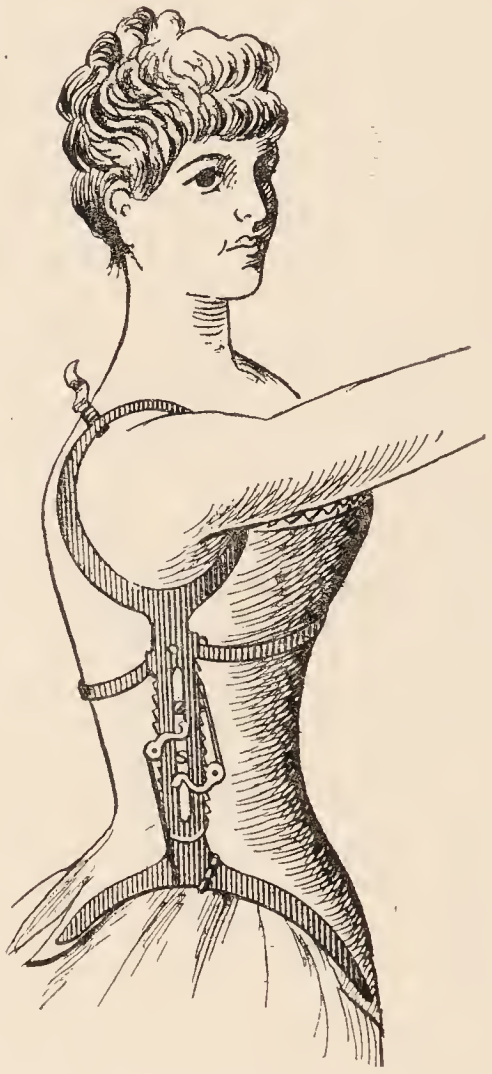


FIG. 9.—Portal's spine brace, 1767. (*Young.*)

be, everyone will rather trust them than go to an executioner; but if the surgeons are ignoramuses, the public must not suffer, but must submit to be treated by the executioner rather than to remain lame and crippled."[1] According to this, today the orthopaedic surgeon has taken the place of executioner.

The foremost English surgeon at this time was Sir Percival Pott (1713–1788). He became surgeon to Saint Bartholomew's Hospital in 1749 and published in 1779 his "Remarks on that kind of palsy of the lower limbs which is frequently found to accompany curvature of the spine." This was the first accurate description of the gross lesions of hump-back, which disease still bears Pott's name.

John Abernethy (1764–1831), Pott's successor at Saint Bartholomew's, introduced an improved method of opening lumbar abscesses "to admit the least possible amount of air."

[1] J. S. Billings, Dennis, System of Surgery, vol. i, ch. 1.

Henry Park (1774–1831) of Liverpool, a pupil of Pott and Le Cat, has his name linked with resection of the knee and elbow, and Charles White of Manchester first excised the head of the humerus in 1768.

Among the English surgeons who wrote of joint and bone diseases may be named Sir Benjamin Collins Brodie (1783–1862), who wrote "Pathological and Surgical Observations of Diseases of the Joints," in 1818; William Ferguson (1808–1877), who devised the term "conservative surgery" in sparing all of limbs possible in bone disease by excisions; James Syme (1799–1870); Edward Stanley (1791–1847); George M. Jones (180?–1861) excised the hip, knee, ankle and scapula; Joseph Sampson Gamgee (1828–1886) devised starched apparatus for fractures and joint disease; Abraham Colles (1773–1843), whose name we use in speaking of fracture of the proximal end of the radius and "Colles' law" of syphilis. W. J. Little, himself club-footed and a patient of Stromeyer's (v.i.), published valuable treatises on club-foot (1837–1839), and "Deformities of the Human Frame" in 1843.



FIG. 10.—Le Vascher's corrective apparatus for Scoliosis, 1768. (*Young.*)



FIG. 11.—Vense's suspension by head and axillae with leg traction for Pott's Disease and Scoliosis. (*Young.*)

Robert Adams (1791–1861) wrote of chronic rheumatic arthritis; Robert William Smith (1807–1873) of congenital dislocations; Henry Hancock (1809–1880) of the foot and ankle joint; John Cooper Forster (1823–1886) of the surgical diseases of children; Peter Charles Price (1832–1864) on excision vs. amputation in knee-joint disease.

In France we find writings by Guillaume Dupuytren (1778–1835), after whom the contraction of the tendons and palmar fascia is named, and who wrote of congenital hip dislocation and subcutaneous tenotomy of the sterno-cleido-mastoid; Philip Joseph Roux (1780–1854) on cleft palate; Jacques Lisfranc (1790–1847) on partial amputation of the foot; Jacques Mathieu Delpeck (1777–1832), who pointed out that Pott's Disease of the spine was of tuberculous origin, and in 1816 first performed tenotomy of the tendo achillis for

talipes equinus, following a Doctor Lorenz's operation at Thilenius' suggestion on a patient of the latter, which was later popularized and applied to this and other tendons by Georg Friedrich Louis Stromeyer (1804–1876) of Hanover in 1831.

Moritz Gerhard Thilenius (1745–1809), of Frankfort on Main, was the first on record, who proposed division of the tendo-achillis for talipes[4] (Figs. 10 and 11). Others of his time and even subsequently blamed the distorted tarsal bones and not the tendons for the primary deformity. On a patient, a girl of 14, on March 26th, 1784, a surgeon by the name of Loranz resected two inches, enabling the patient to tread on the entire sole. The foot was retained in its improved position by appropriate bandages and the cicatrization of the large wound was complete on the twelfth of May. The cure was so perfect that the patient walked as well as a sound person." Following this case Sartorius operated on a case of equinus in a boy of 13 who had had abscesses on the "back of the leg" six years previously (probably from a tuberculous ankle). He dissected out the tendon through an incision four inches long, then divided it. Great force was necessary to correct the deformity (from evident ankylosis at the ankle), and Sartorius was much censured for this forcible correction, although "the result in nine weeks was satisfactory."

Michaelis in November, 1809, operated on his first case "by dividing the tendon one-third through and immediately corrected the deformity." He subsequently operated on seven other cases. As previously stated Delpech in May, 1816, made a punctured wound (the first attempt at subcutaneous tenotomy) of an inch on either side of the tendo achillis in a boy of nine years, divided the tendon from within out with a second knife, corrected the deformity and then manually tried to bring the severed ends of the tendon together, applying fixative dressings, as his idea was that union would be more satisfactory if the deformity were later corrected mechanically while the lymph was "still soft and possessed ductility." As it happened the case suppurated and "indolent abscesses were formed on the inside of the leg, the inside of the patella and in the inguinal region; and neither these nor the wounds from the operation were healed for some months." The patient was ultimately cured, but Delpech did not record another case of tenotomy but laid the rule that "the tendon should not be exposed, but section should be done by a circuitous route."

Fifteen years later Stromeyer, in February, 1831, made a much smaller puncture with a tenotome on a case, endeavored not to puncture the skin on both sides, although he said it did not matter. He did not believe in immediate but subsequent correction of the deformity by mechanical means, a foot stretcher and Scarpa (Antonius Scarpa, 1747–1832) shoe, and on this case and 150 more he succeeded and made the operation permanent.

Others of the same period who wrote of joint surgery were Alfred Armand Louis Marie Velpeau (1795–1867), whose bandage we use in clavicular and shoulder joint conditions; Amèdèè Bonnet (1802–1858), who made useful studies in spinal and joint diseases; Charles Gabriel Pravaz (1791–1853), who first put orthopaedic surgery on a scientific basis; Jean Gaspard Blaise Goyrand (1803–1866), who wrote of loose bodies in the joints; Jules Roux (1807–1877), who first

[4] Adams, Club-foot. Lindsay and Blakiston, 1873.

made use of iodine injection into the shoulder joint; Henry Ferdinand Dolbeau (1830–1877), who contributed to our knowledge of club-foot and spina bifida, and Joseph Francois Malgaigne (1806–1865) of dislocation and fractured patella.

Jules Réné Guérin (1801–1886), the founder of the Gazette médicale de Paris specialized in orthopaedic surgery and established a private sanitarium. His first book on deformities appeared in 1838 and in 1882 the "Oeuvres du docteur Jules Guerin," etc., which were to fill 16 volumes were started, but never finished. He was more popular as a critic and writer with the laity than the profession.

In Germany we find Johann Friedrich Dieffenbach (1792–1847) practicing orthopaedic surgery in 1832; Michael Jaeger (1795–1838), who wrote largely of diseases of bones and joints; Friedrich August von Ammon (1799–1861) devoted much attention to deformities; Bernard Rudolph Konrad von Langenbech (1810–1887), who broadened surgical knowledge in nearly every depart-

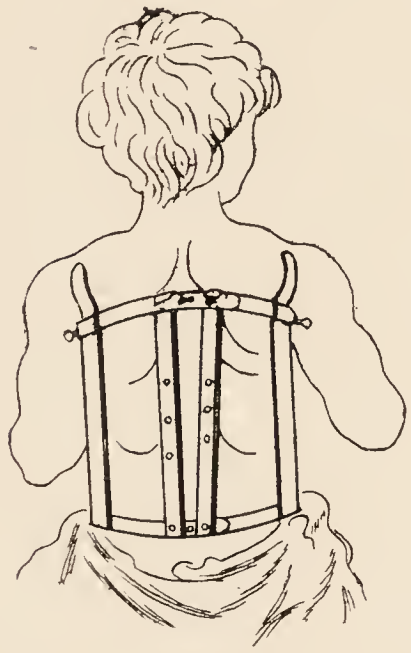


FIG. 12.—Schmidt's spine brace, 1794. (*Young.*)

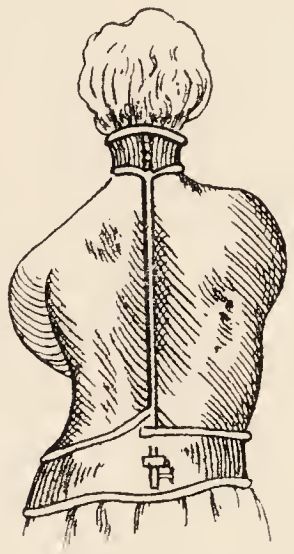


FIG. 13.—Kohler's collar and spine brace, 1795. (*Young.*)

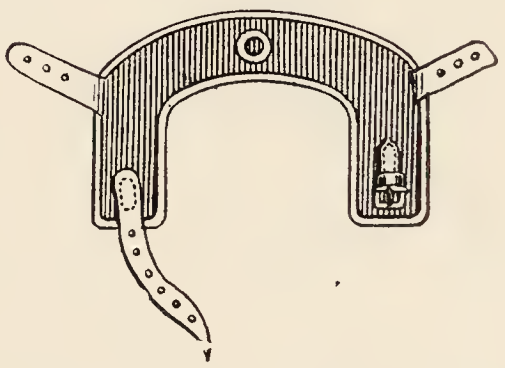


FIG. 14.—Glisson's suspension collar, 1799. (*Young.*)

ment; Carl Hueter (1838–1882), who wrote treatises on joint diseases in 1870 and 1876; Theodor Billroth (1829–1894) threw much light on surgical pathology, and Richard von Volkmann (1830–1880), one of the founders of the German Surgical Association, devised the bone curettes known as "Volkmann spoons."

In this country much was added to our knowledge of orthopaedic surgery by Doctor Nathan Smith of Yale (1762–1829), who first used a trephine in osteomyelitis and introduced manipulative means to reduce dislocation of the hip joint; by Doctor William C. Daniel of Savannah, who first employed extension by weight in the treatment of fracture of the femur; by Doctor J. Kearney Rodgers (1793–1851), of New York, who did an osteotomy in ankylosis of the hip in 1840, following Doctor John Rhea Barton (1794–1871) of the University of Pennsylvania, who first performed this operation in 1826.

Thomas Dent Mutter (1811–1859) of Virginia, later of the Jefferson Medical College, added to our knowledge of plastic operations to correct deformities following burns.

Henry Jacob Bigelow (1816–1890) of Harvard excised the first hip joint in this country in 1852.

Gurdon Buck (1807–1877) of New York popularized the treatment of fractures of the thigh by weight and pulley, which is now so much used in contractures, especially in muscle spasm in tuberculous disease of the spine, hip and knee joints, and known as "Buck's extension."

Alden March (1795–1869) of Albany made valuable investigation of hip disease.

John M. Cornochen (1817–1887) of Savannah wrote on congenital dislocations of the head of the femur. Robert Alexander Kinloch (1826–1891) of Charleston, S. C., who was medical director on the staffs of Generals Lee, Pemberton and Beauregard in the Civil War, first successfully in this country excised the knee for chronic disease.

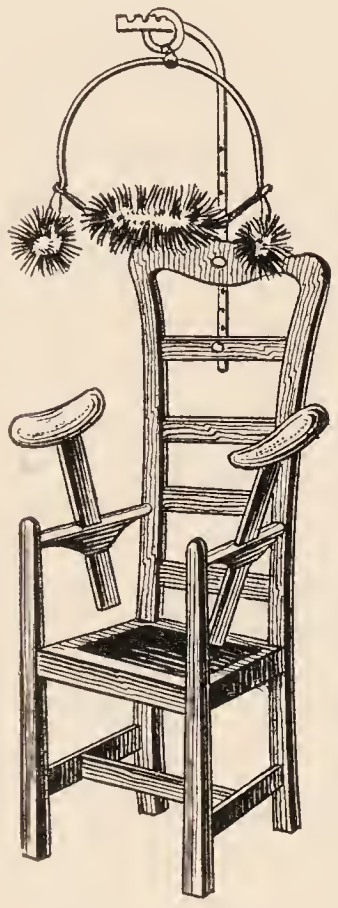


FIG. 15.—Darwin's suspension and corrective chair, 1801. (*Young.*)

Henry C. Davis devised the traction splint for tuberculous hip disease and the antero-posterior support for Pott's Disease.

Along with the introduction of anaesthesia in 1846 by Doctors John Collins Warren (1778–1856) and Henry Jacob Bigelow (1816–1890) of the Harvard Medical School (after Doctor Crawford W. Long of Athens, Ga., in 1842 and Doctor Morton, a Boston dentist, had independently produced insensibility by ether), and the introduction of antiseptic and aseptic surgery by Sir Joseph Lister in 1867, on the basis of Pasteur's experiments, which proved that putrefaction is due to the action of microorganisms, orthopaedic surgery partook of the general new life infused into surgical practice and became more and more specialized and operative in the nineteenth century. Bigelow published a "Manuel of Orthopaedic Surgery" in 1844, and he may be regarded as the father of this specialty in America.

More recently the names of Buckminster Brown of Boston, James Knight, Louis A. Sayre, who made the plaster bandage and jacket popular and Charles Fayette Taylor of New York stand out as laying the foundation upon which has been built the American School of Orthopaedic Surgery and the results of whose teachings are found in the Transactions of the American Orthopaedic Association, which was established in 1887. These Transactions today represent the most original, advanced, suggestive and thorough work done in this specialty in America and are now published as the Journal of Bone and Joint Surgery.

The late Doctor William Detmold held private clinics at Bellevue Hospital, New York, in this specialty as early as 1841, and in the New York Medical Gazette, January 1st, 1851, vol. ii, we find an editorial to the effect that, "Doctor Detmold has consented to deliver a course of lectures on orthopaedic surgery, a department in which he has long been distinguished and the importance of which can scarcely be overrated." However, regular orthopaedic work was not begun at Bellevue Hospital, until Louis Albert Sayre was appointed visiting

surgeon in 1853. In 1861, Bellevue Hospital Medical College was organized and the first chair of orthopaedic surgery was established with Doctor Sayre professor, as has been noted in the beginning of this historical sketch.

The first special institution for the crippled was advocated by Doctor James Knight in New York as early as 1842, but it was not until 1863, that the valuable Hospital for the Ruptured and Crippled of New York City was finally incorporated with Doctor Knight as surgeon-in-chief, although for 20 years he had specialized in orthopaedic surgery and was noted for his philanthropy.

Doctor Charles Fayette Taylor, the then consulting orthopaedic surgeon to Saint Luke's, established the New York Orthopaedic Hospital in 1866. The Boston Children's Hospital, which is one of the most thorough and advanced institutions for the treatment of deformity existing today, was incorporated 1869, chiefly through the efforts of Mrs. Francis H. Brown and William Ingalls.

Here in Baltimore, the writer founded the Hospital for crippled and deformed children, the first Orthopaedic Hospital, South of Philadelphia in 1895; its branch, the Mountain Hospital for crippled children was established in 1897 and continued for Summer use only, until 1910, when James Lawrence Kernan gave "Radnor Park" of Seventy-five acres in north-west Baltimore and a large endowment to this institution, which has since borne his name.

Following the introduction of antiseptic and aseptic surgery, a new school of operative bone and joint surgery developed and received great stimulation from the able leadership of such men as Doctor Edward H. Bradford of Boston, Doctor Virgil P. Gibney of New York and Doctor John B. Murphy of Chicago, to whom the majority of the able American orthopaedic surgeons of today owe much of their early training.

Recently abroad Sir Robert Jones, Albert Hoffa, Fritz Lange and Adolph Lorenz stand out conspicuously as investigators and teachers.

CHAPTER II

FIXATION DRESSINGS

The Plaster of Paris Bandage.

Perhaps there is no dressing or splint more useful and necessary to the surgeon than a good plaster of paris bandage, where prompt fixation of a part in a certain given position and relationship to other parts is desired. A bad bandage may spoil an otherwise successful operation and convert a most skillful and gratifying result into a mortifying failure.

The factors which tend to produce poor bandages are: first, materials poor in quality; second, poor technique in the making; third, deterioration from improper care, such as premature exposure to moisture; and fourth, improper method of wetting and wringing.

Plaster of Paris.

Plaster of paris is very finely ground calcium sulphate or as it is more commonly known, alabaster, which has been subjected to high heat and all its moisture driven off. It then becomes an exceedingly fine powder, which is hygroscopic or possesses the quality of attracting moisture, absorbing it and rapidly hardening back again into marble, or, as we term it, "setting." Premature exposure to moisture necessarily, therefore, produces a premature "setting," which results in an already "set" and useless substance, when the scientific application is required later. When nurses are handling plaster of paris, this fact should be borne in mind. Good results may not be expected on a rainy day by an open window or in a room into which steam or moisture is escaping from the sterilizing room, if chosen when bandages are made.

Plaster of paris for bandages and surgical casting must be of the best quality and we have recently found French's Dental Plaster of Paris the most satisfactory. This is prepared in Philadelphia and comes in covered tins, kegs and barrels. When required in large quantities for the larger hospitals, where many bandages are used, it is more economical to buy in kegs or barrels, but *upon receipt* at the hospital it should be transferred at once to *covered* tins and *not kept* in the barrel *in a damp cellar*.

Crinoline.

The other material used for making plaster of paris bandages is *starch* crinoline. Crinoline containing glue, such as dressmaker's ordinary crinoline, is unsuitable, as the glue retards very appreciably the setting of the plaster and it may be hours in hardening, which makes it burdensome or impossible for the surgeon, assistant or nurse to hold the parts in position until the desired result

is attained. This surgical crinoline is made by A. Claflin Company, West Broadway, New York, and we have obtained ours of late from Gibson and Company, 917 G Street, N. W., Washington, D. C. This crinoline comes in 24-yard lengths and it is desirable to have the bandages six yards long and torn in strips two, three and four inches wide, as bandages may be required for different parts of the body, in children or adults. Two threads should then be pulled from the torn edges, as ravellings coming out during application are most annoying.

Technique in Making Plaster of Paris Bandages.

After choosing a rather warm and dry room (Fig. 16) the nurse should have a small table covered with mackintosh or rubber sheeting, on which is the

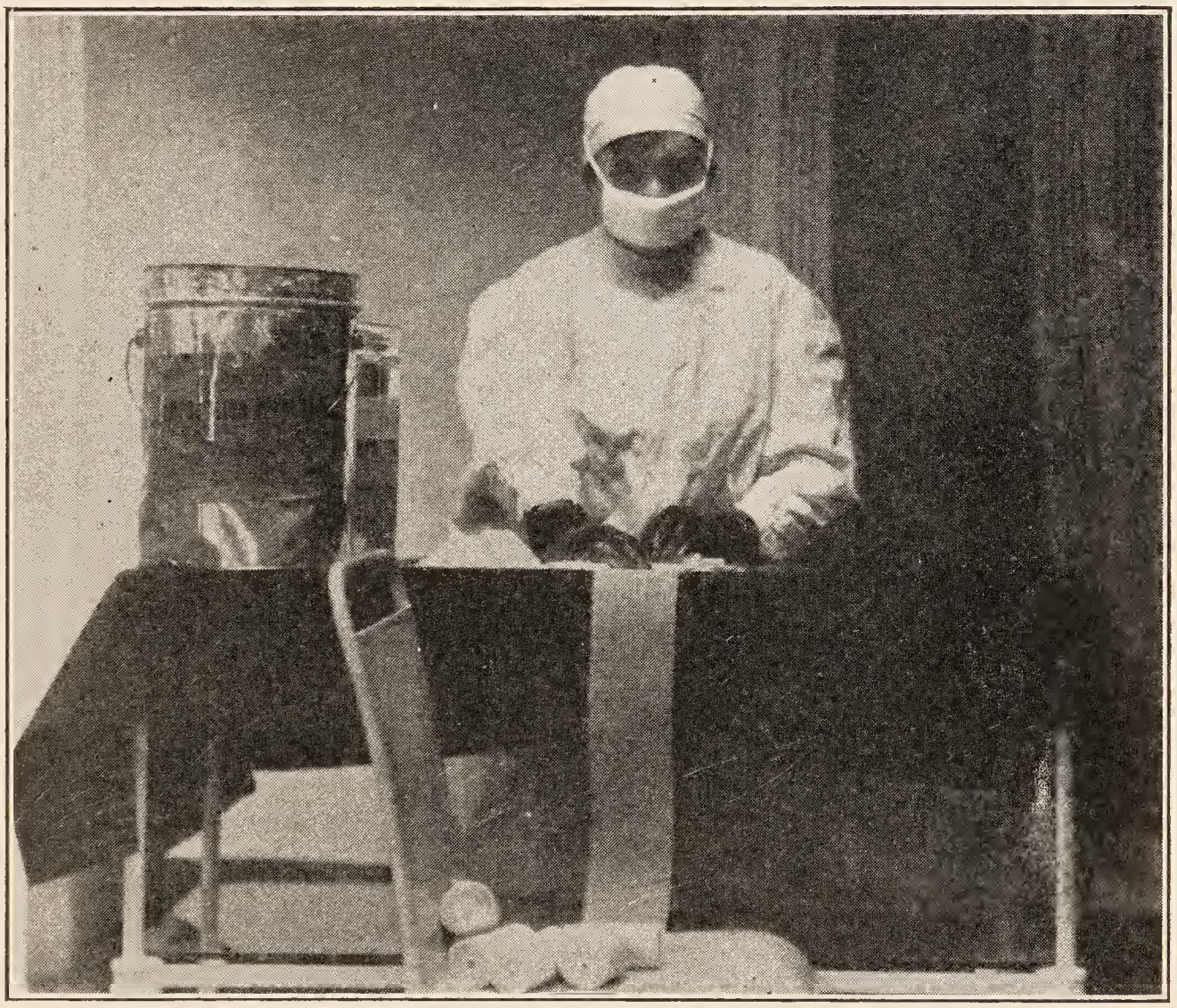


FIG. 16.—Technique in making plaster of Paris bandages.

covered tin of plaster of paris and an empty covered tin for the reception of the bandages as made, both preferably on her right. The strips of torn crinoline are on a chair on the opposite side of the table facing her and should be pulled as needed over the edge of the table so that they are *begun* and rolled *entirely* with her left hand, which is *imperative*, in order that they may be rolled loosely and when immersed in water, it may penetrate readily to all parts, which is not possible, if there is a solid core. With the right hand, or with a spatula, the powdered plaster of paris is rubbed well into the crinoline, so that all meshes are filled. Some nurses prefer for protection to put on rubber gloves in making these bandages, an operating gown and gauze mask over nose and mouth, as the fine powder produces a disagreeable dryness in mouth and

throat, if breathed in. It is desirable to take out from the supply-tin only enough plaster of paris at a time to complete two or three bandages. Bandages on completion should be carefully placed in the tin receptacle and the cover replaced on it. It is superfluous to wrap each bandage in Japanese crepe- or tissue-paper, as the bandages will keep moisture-free in a covered tin for years and the saving of plaster of paris dropping out of the bandages, either in the tin or the bowl of water is insignificant. The removal of the tissue-paper from the bandage, when soaked, is "messy" and time consuming, the plaster saved is hardly worth the trouble. It is needless to say that the bandages remain in the covered tin until required in the operating room. Different widths should be separated and each tin should be labelled with a strip of adhesive plaster indicating two-, three- or four-inch bandages, as the case may be. They should *not* be assorted in one tin, because much plaster is lost, if a nurse has to fuss around in a tin to find among the twos and threes, another four-inch bandage for the operator. Many heedless nurses thus mix up the different widths. In institutions where many plaster of paris bandages are used, the very ingenious and efficient electric driven plaster bandage machine devised by Doctor Compton Riely of the University of Maryland is recommended.

CHAPTER III

FOUNDATIONS FOR, APPLICATION AND REMOVAL OF PLASTER BANDAGES

Indications for Plaster Splints.

Plaster of paris casts or splints are used for various purposes, which may be summed up in the term "Fixation." Thus they are most useful in fractures of all kinds, such as those resulting from surgical operative corrections, like bow-legs and knock-knees; "recent" fractures in which casts ample glazed cotton is used underneath and the cast is bivalved; "compound" fractures where

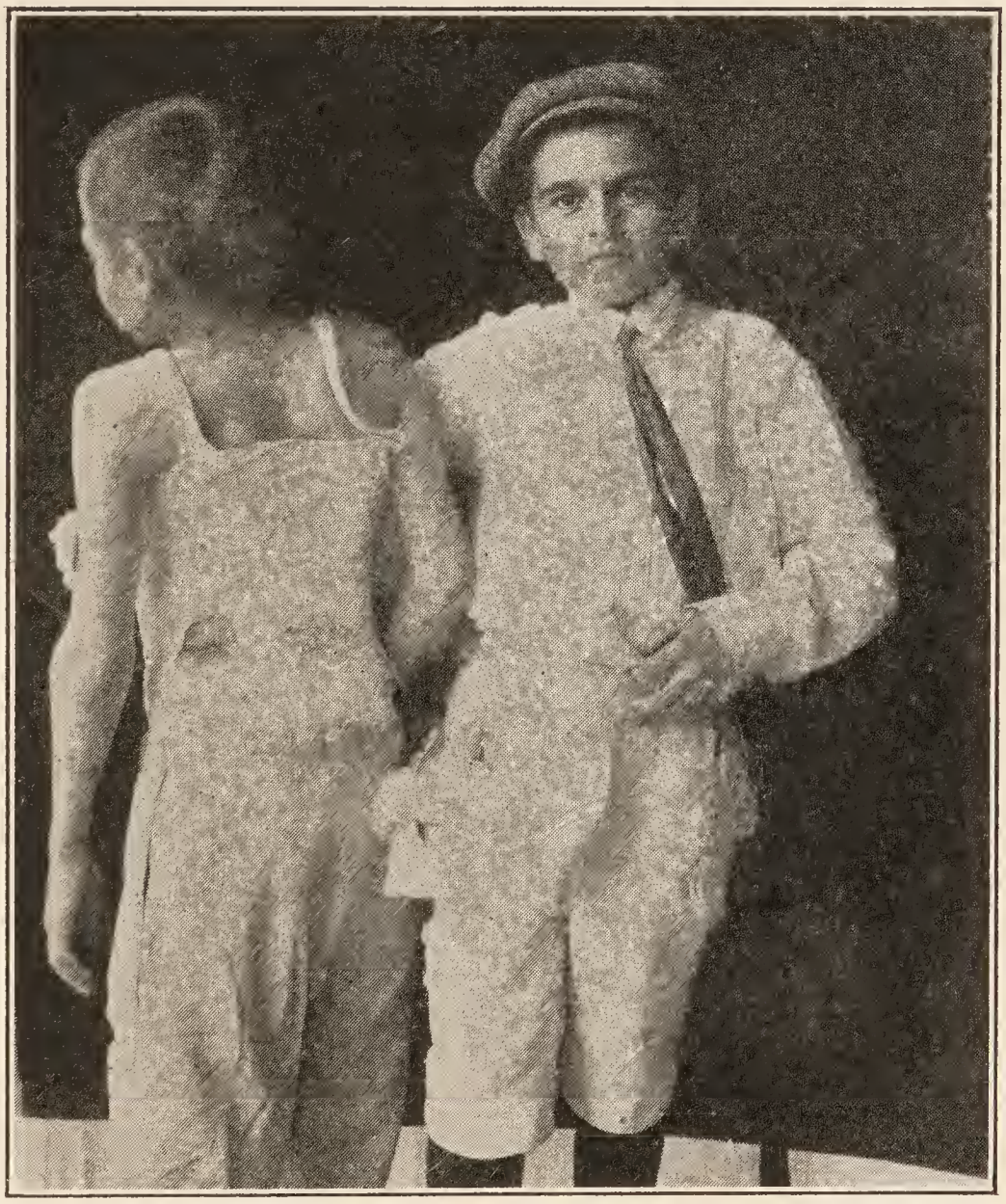


FIG. 17.—Plaster cast with window showing sinus from spinal tuberculosis. Sinus from hip disease also shown.

it is necessary to have "windows" cut in the cast to permit removal of soiled dressings from the open wound. In many of these last named cases the Balkan Frame and Hodgen Splint are used, as will be detailed later. In all fractures, the application of the cast is to secure fixation or immobilization, so that there may be maintained perfect alignment of the component pieces of broken bone

and healing may result in the restoration of the bone to as near its normal former condition as may be possible under the circumstances.

Dislocations also call for the use of the plaster dressing, after operative "reduction" has been accomplished, to hold the two or more bones in proper relation to each other until the soft parts, which were torn or stretched when the dislocation occurred have healed or shortened up to maintain the normal condition. These uses are applied to both the congenital and traumatic varieties of dislocation.

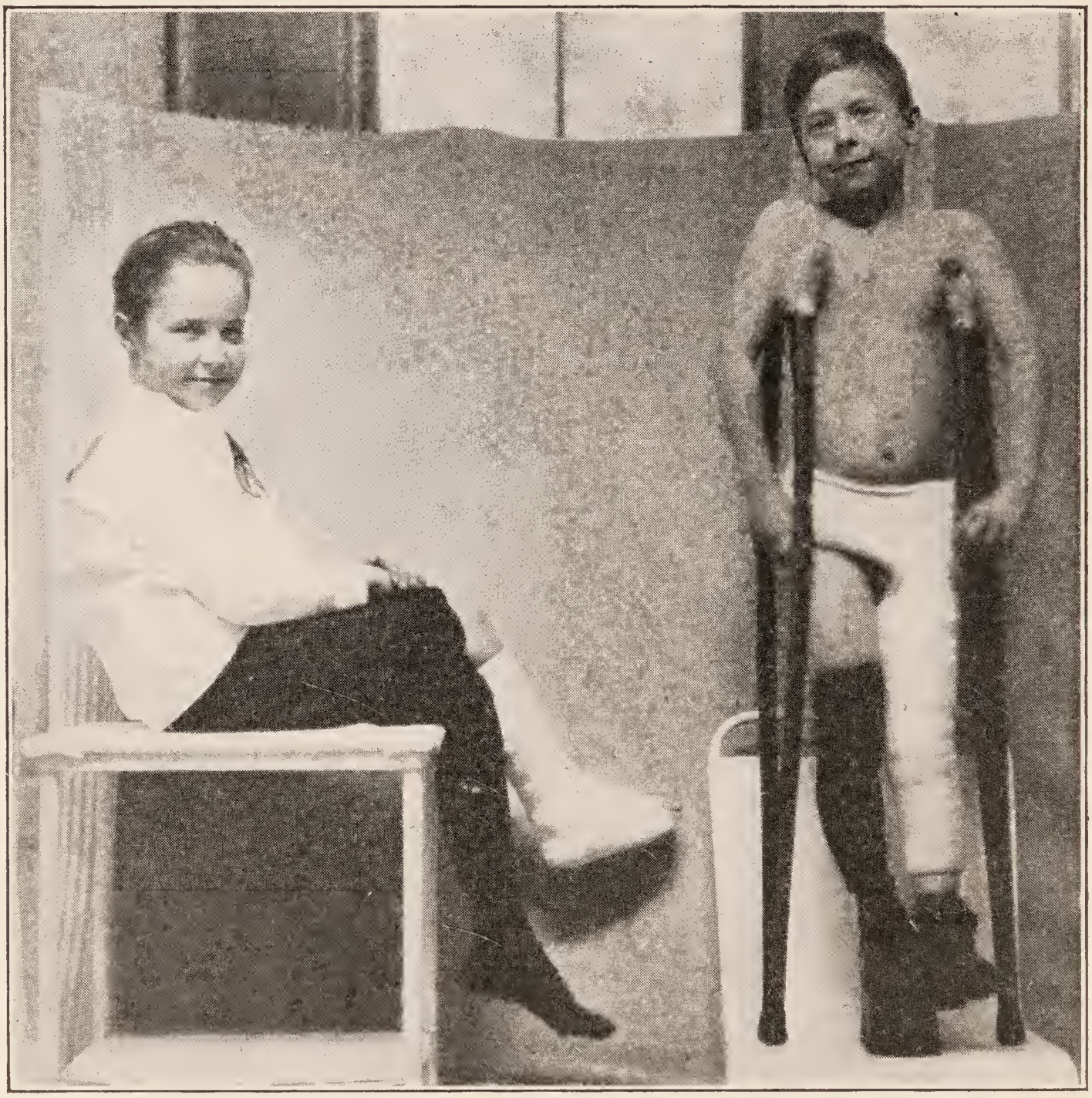


FIG. 18.—Plaster cast for fixation of ankle and spica for hip disease.

Certain sprains, or the tearing of ligaments in the spine, sacro-iliac joints, ankles, knees, et cetera, may be of such severity as to call for the use of the plaster of paris dressing, when the ordinary surgical adhesive plaster proves inadequate.

A limited number of nerve lesions associated with partial or temporary paralysis from tearing of nerves, oedema, which impairs or weakens the nervous conductivity, or inflammations at nerve centres, may call for immobilization of the parts involved in the region of that nerve's distribution to lessen strain and promote healing. Types of this use may be cited, as in "wrist-drop," brought about by weakness of the extensor group of muscles from insufficient

innervation and the deformity resulting from gravity. Thus the plaster cast holds the hand in what is known as a "cock-up" position or in extension, until such time as the extensor muscles regain their power. Similarly, after obstetrical paralysis of the shoulder or Erb's Palsy, it has been found that the tearing of the cervical plexus at birth with the resultant loss of power in the outward rotators of the shoulder can be greatly benefited or cured by putting the arm up in plaster of paris rotated outward and at right angle with the body.



FIG. 19.—Covered split plaster cast for wrist drop fastened with webbing straps and buckles.

Another application for nerve lesions is found after an attack of Infantile Paralysis to rest the involved parts and in other cases to prevent "post-paralytic contracture," produced by the "over-action" of unparalyzed groups of muscles at the expense of the partially or temporarily paralyzed groups. This application is seen especially in cases of "Foot-drop," hyper-extension of the knee or outward rotation and abduction of the thigh (Figs. 18, 19, 20 and 21).

Plaster of paris casts are used to immobilize joints or adjacent bones in which there is present some active inflammatory process, with a view to allowing healing or encapsulation and if possible, to prevent extension of the disease

to joint surfaces and structures thereby destroying the normal function of the part. This use is especially applicable to tuberculosis of the joints and spine. In acute open pyogenic infections of joints, it has been pointed out by Willms that, it is better not to immobilize the joint with plaster of paris or other splints, but to encourage the patient to actively move the joint or even for the surgeon or nurse to give passive motions to it to force out purulent exudations, as giving a better chance of synovial repair and articular restoration.

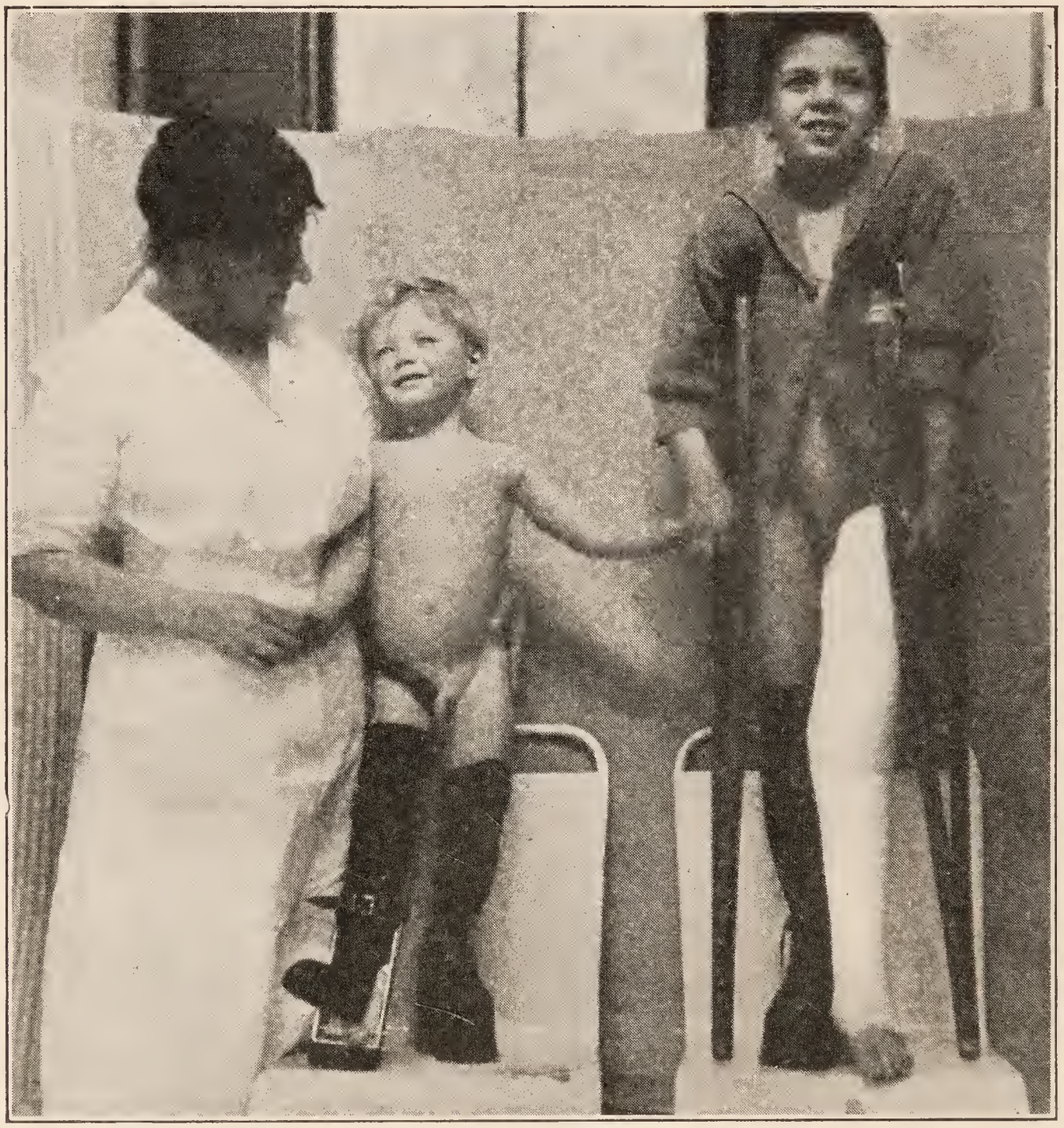


FIG. 20.—Plaster cast for tuberculosis of the knee and Thomas knee splint with traction windlass. (Author's Modification.)

Preparation of the Patient for Plaster of Paris Bandages.

On account of hair on the surface of the skin, plaster of paris bandages must have some material interposed, such as non-absorbent glazed cotton, undershirts or stockings, or preferably, what is known as Seamless Stockinet, which comes in 10-yard rolls of different circumferences suitable for extremities or the body.

There are also in thin people frequently, bony prominences or projections which have to be padded to prevent excoriation from the hardened plaster. This is best done by felt. The stockinet is to be had from Joel Gutman and Company, Baltimore, Maryland, and the felt from the American Felt Company. Of the latter, the most useful for surgical use is about ¼ of an inch thick, as

it adapts itself to the body contour more readily than the heavier grades. It comes in white and grey.

It is frequently desirable not only to line the plaster cast with the stockinet, but also to cover the cast itself with the stockinet; if this is desired, twice as long a piece of stockinet is cut as the plaster cast will require as a lining, so that the inner stockinet at only one end will have to be sewed to the outer and the dressing is much neater than it would be otherwise (Fig. 22).

Preparatory to applying a plaster jacket to a patient, the nurse, after bathing the patient's body with soap and water and an alcohol rub, should apply the body stockinet and pin it over the shoulders, having previously slit it under the



FIG. 21.—Plaster cast for obstetrical paralysis.



FIG. 22.—Calot jacket for cervical Pott's disease showing method of pulling up stockinet to cover outside.

arms to permit this. It should then be pinned between the legs with a safetypin to render it tight and smooth. Any bony prominences, such as the anterior superior spines, the prominent ribs or vertebra, et cetera, should be covered with felt of sufficient size sewed to the stockinet.

Preparatory to applying a spica to the pelvis and leg, the nurse, similarly, should use body stockinet from the groin to the sternum and leg stockinet from groin to knee or foot or beyond, as the surgeon may desire it covered or not on the outside. The body stockinet and leg stockinet are then stitched together and the felt placed on the anterior superior spines and iliac crests, if needed, in thin subjects.

Immersing Bandages in Water and Wringing.

Large China bread bowls or agate-ware bowls of ample size *full of water* furnish the best receptacles for wetting plaster bandages: the large size being required as the water in small containers soon becomes saturated with plaster and the later immersed bandages will present unsaturated dry spots which interfere with smooth uniform results in application.

In placing the bandages in the water, the nurse should hold it lightly with both hands over the ends to prevent excess of plaster escaping and facilitate wringing. When bubbles cease to escape, the nurse then compresses the ends, *squeezing the plaster into* the bandage until but little water drops and the bandage has a rich creamy feeling. It is then to be handed to the surgeon.

In no case should the bandage be squeezed or wrung with one hand or until very dry, as it will be found to consist chiefly of crinoline, whereas we wish it to consist chiefly of plaster and secondarily of crinoline. It is not advisable to put in but one bandage at a time, as the second bandage will partially set before it can be applied.

Emptying the Plaster Water.

The bowl that has been used for wetting plaster bandages with its contained plaster solution *should not* immediately be emptied into a sink. Allow it to stand for a time until the supernatent water clears and the plaster settles to the bottom and *sets*. *The water*, now clear, can then be poured off and the cake of settled set plaster put in the soiled-dressings bucket. Nurses will thus avoid needless and careless plugging of waste-pipes and annoyance and expense from this source in hospitals, offices and private homes.

Thickness of Plaster Casts.

In applying plaster bandages one should begin at the bottom or top, it matters not which, and the bandage rolled around the part *without tension* in a progressive manner, overlapping the previous turn one-half or three-fourths, until the whole length desired is covered. Then one should begin at the beginning again and repeat the procedure. As a rule, two layers of this kind are ample with good bandages and three layers at most. The resultant cast is from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch thick. When great strain will be exerted on a part plaster turns reduplicated must be employed. A cast need not be thicker than $\frac{1}{2}$ inch for a heavy individual. Thicker casts are burden-some and unnecessarily uncomfortable to the wearer.

To Cut and Remove Casts.

Plaster casts are most easily removed with a thin-bladed, hook-shaped knife such as employed by linoleum- or oil-cloth-cutters. The blade is not much thicker than a safety-razor blade and keenly sharp. The hook-shaped end tends to cut away from the patient. A line is cut in the cast and this is deepened by going from one end to the other, over and over again, until the whole length is cut through about at the same time.

At times the plaster is very hard and a medicine dropper and medicine glass of water should be at hand, so that a few drops can be dropped in the cut as the knife proceeds. This greatly facilitates the procedure (Figs. 23 and 24).

In no instance is it necessary to cut a trough in the plaster, as one often sees done, but the cut should be straight through, especially if the cast is to be reapplied or finished by the leather-worker with eyelets or hooks in the leather



FIG. 23.—Plaster knife, dropper, glass and bandage scissors.

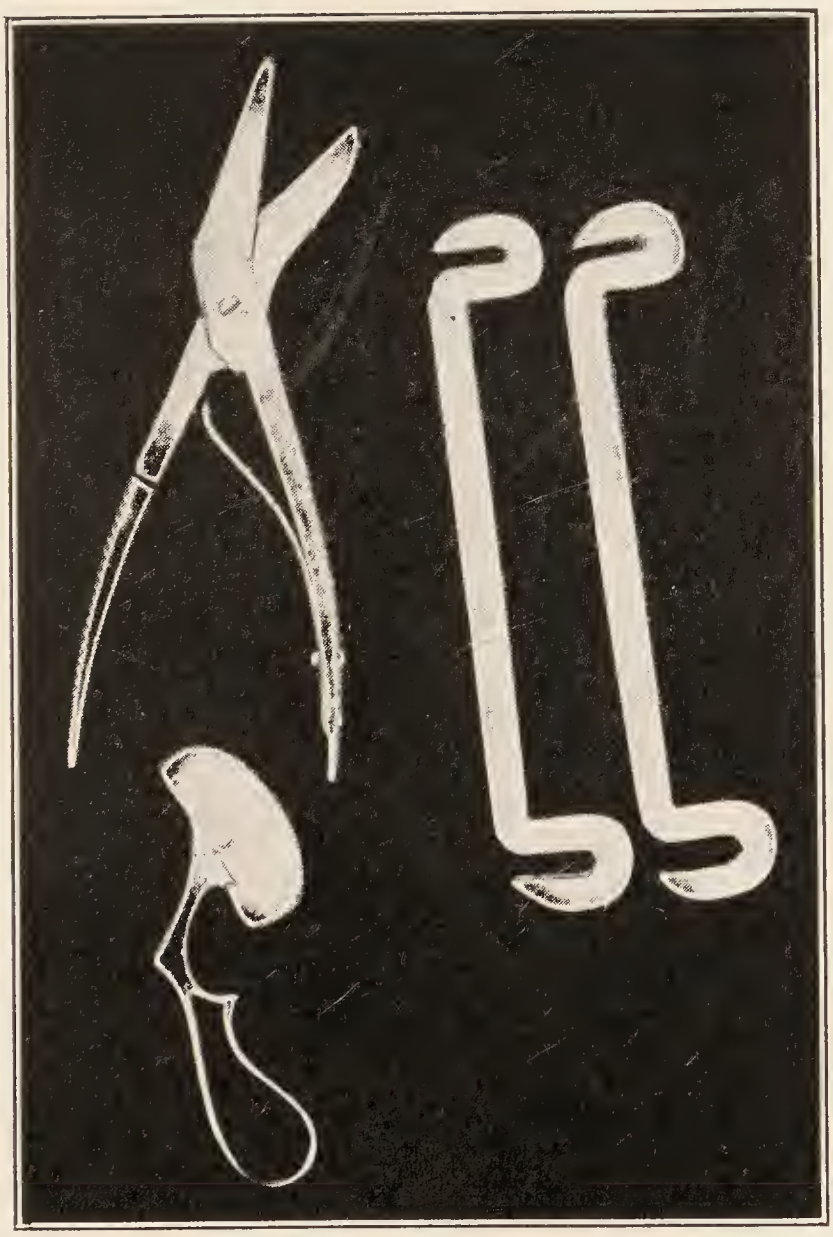


FIG. 24.—Plaster saw and shears. Bending irons for brace adjustment.

edgings, for lacing. Caution of course is to be observed in the deepest layers to safe-guard the patient's skin by a sense of the operator's feeling of the difference in the texture of the plaster and the underlying stockinet or glazed cotton.

After the plaster is cut through, the edges of the cast can readily be sprung apart ½ inch or more to permit cutting the stockinet or glazed cotton with blunt-pointed bandage scissors.

After this is done, the cast should be carefully sprung open from top to bottom more and more, again and again, just as one would open a new book, until it can be removed from the extremity or trunk. It will be found advantageous and more comfortable to the patient, with less likelihood of breaking the cast, for two persons to remove it, standing behind the patient, one springing open the upper edges and the other the lower edges. Immediately on removal of a



FIG. 25.—Plaster jacket made to lace covered inside and outside with stockinet.

cast, especially one that is to be "finished" and reapplied later and is "green" or not thoroughly dry or hard, its edges should be approximated and it should be bandaged with a gauze bandage to preserve its shape and prevent warping. It is to be then hung up to dry thoroughly in a warm place before sending to the finisher (Fig. 25).

Casts applied to the leg and foot should be *cut down the back of the leg* and sole of the foot as cutting over the instep is difficult and the cast is hard to spring off.

In cutting off a spica on the hip for finishing, it is desirable to cut it vertically down over the *pelvis on the well side*, just posterior to the anterior superior spine and down the *inner* side of the effected leg.

CHAPTER IV

TREATMENT OF MUSCLE SPASM

Traction or Extension Apparatus.

Certain diseases or disabilities produce muscular or neuro-muscular irritation, which is followed by spasmodic, intermittent, prolonged or habitual muscular contraction.

This muscular contraction, depending on the type, may produce pain from muscular cramping or forcing two inflamed surfaces together and further destruction of a pathologically softened tissue, such as a tubercular articulation or may produce deformity from distortion of a limb in an habitual and abnormal position of a limb or the trunk.



FIG. 26.—Hyper-extension plus head and leg traction.

Surgical experience has taught us that sudden forcible combating of this muscular contraction often intensifies the pain or deformity, whereas a gradual steady pull in the proper direction, by weight, spring or screw forces, will correct the trouble and restore the parts to a normal position and in some instances cure the causative disease.

Certain apparatus has been devised to effect this pull, which is known as Traction or Extension Apparatus (Fig. 26). Such apparatus is more often applied to the lower extremities than elsewhere and is here spoken of as "Buck's Extension," after the inventor, Doctor Gurdon Buck. Other applications of traction are found in the Head-Sling for spinal extension, adhesive traction of the fingers to correct deformities in the hand, as in the Lewis or Skirball Splint, and in the treatment of arm or leg fractures by the Balkan Frame, which

will be discussed later. The Thomas Leg (Fig. 20) and Arm Splints (Fig. 85B), and Jones Rectangular Arm Splints (Fig. 27), so much used for compound fractures in the War, are also types of Traction Apparatus for transport or ambulatory purposes.

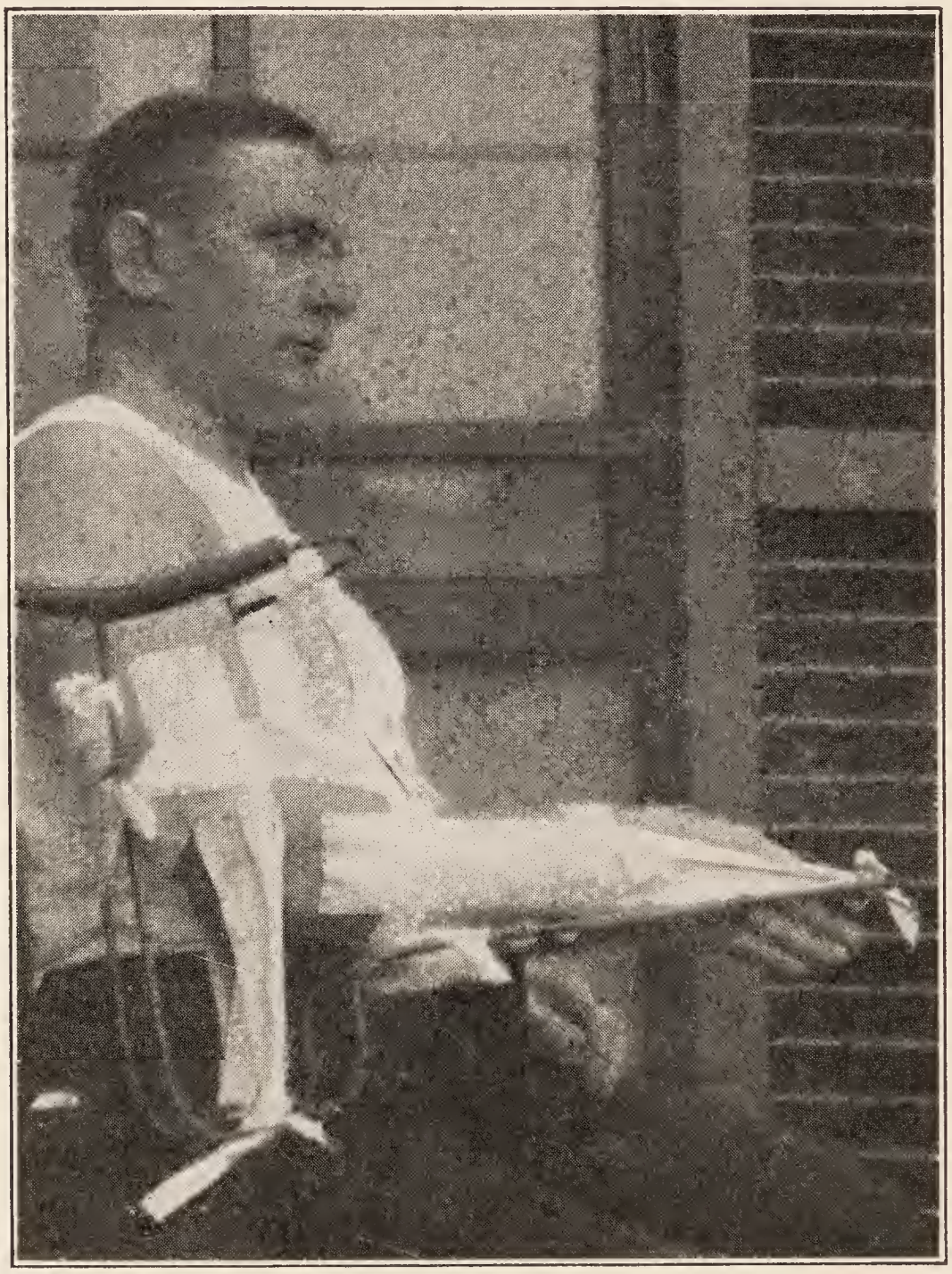


FIG. 27.—Jones rectangular arm splint for fractures of humerus showing traction on arm and forearm.

Buck's Extension.

This consists of adhesive or surgeon's plaster stuck on the sides of the leg and terminating below the foot at a "spreader," which prevents painful pressure against the ankle bones or malleoli. In the centre of the spreader a rope or cord is attached, which passes over a pulley at the foot or side of the bed and has the weight attached to it.

Four types of adhesive are used to effect this pull on the leg. In the use of the Balkan Frame, over-seas, especially in the British Army, canton-flannel strips attached to the side of the leg or arm by glue were extensively employed, and also mole-skin plaster, but the other two methods, viz., the ordinary Zinc Oxide Surgeon's Plaster and Shiver's Swans' Down Adhesive find the greatest popularity in the American clinics.

The details of the technique in application of these two methods deserve the most careful observance on the part of the orthopaedic interne or nurse as a saving of time and material in the long run and to promote the comfort of the patient (Fig. 28).

Z-O Adhesive or Two-tailed Traction Straps.

Z-O adhesive comes in various widths and for Hospital use, we usually purchase the five-yard rolls 12 inches wide made by Johnson and Johnson. It is cut or torn in strips of the desired length and width. Its advantages are that it is less costly than Swans' Down Adhesive, more easily applied and readily

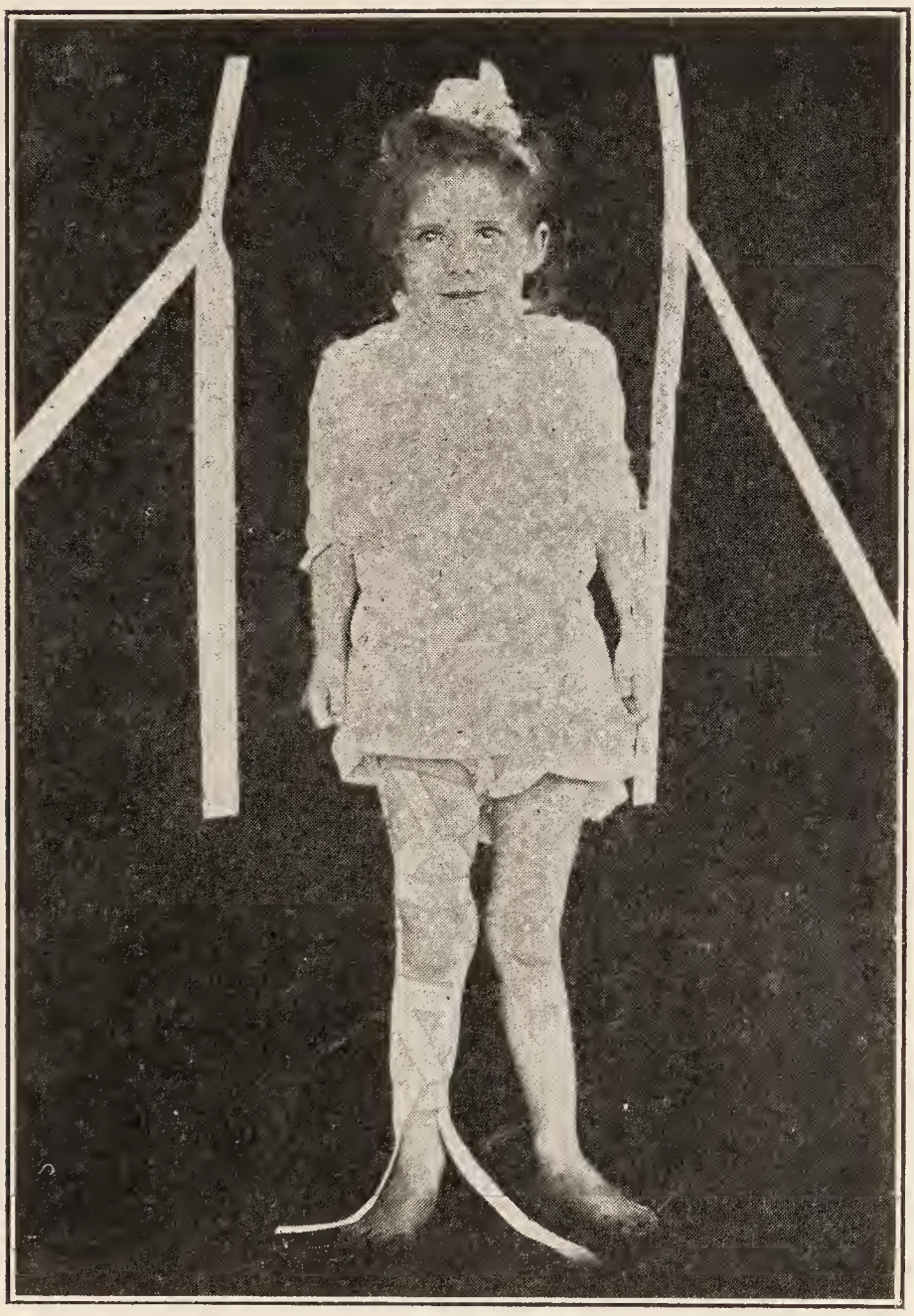


FIG. 28.—Buck's extension, two-tailed straps.

adherent. Its disadvantages are that it is more irritating to the skin and not nearly as adherent for a prolonged period, i.e., it should be changed at least once a week, which is detrimental and a source of discomfort to a patient with such conditions as a recent fracture or acute tuberculous joint, when movements of a part should be avoided, if possible. In an adult with a hairy leg or arm the part should be shaved before the adhesive is applied.

Two strips of adhesive two inches wide are torn and cut as long as the patient's leg, measured from the anterior superior spine to the internal malleolus. On one end of each of these the adhesive surfaces are stuck together two or three inches and to this double adhesive is sewed securely a piece 10 inches long of

¾-inch webbing (obtained from John D. McGonigle and Company, 1125 East Baltimore Street, Baltimore, Maryland, in 10-yard rolls).

With the leg fully extended, beginning two inches above the malleolus at the point where the webbing and adhesive join, the strip is applied vertically to the side of the leg and the plaster made to adhere smoothly up to the knee, then the skin and elastic subcutaneous structures of the thigh are pressed downward with the fingers toward the knee and the adhesive stuck to the thigh. By this procedure, it will be found that the adhesive lies flat, pulls and does not wrinkle. Similarly, the other piece is applied to the opposite side of the leg.



FIG. 29.—Buck's extension, five-tailed straps.

Then two strips of adhesive one inch wide and 10 inches longer than the first two are torn off and applied in a *spiral* direction. One, beginning at the adhesive above the internal malleolus and the other above the outer malleolus. These should be wrapped around without tension in order not to constrict the circulation.

Last of all four one-inch strips similarly applied without tension should be put *transversely* around the leg near the webbing, around the calf, above the knee and at the top of the vertical strips on the thigh (Fig. 28).

A four-inch gauze bandage, previously rolled, so that it has had one inch turned over, out and at its lower edge, when held in the right hand, is applied in the following manner: A transverse turn is applied from left to right over and then under the point where the webbing and adhesive are sewed together. It is then carried obliquely upward to the top of the calf and a transverse turn is taken around here and returned obliquely down so as to overlap the last lower turn. This anchors the beginning of the bandage in place. It is then completed to the knee in oblique spiral half over-lapping turns to the knee, when transverse turns are applied to the top of the dressing, the final turns having the upper edge turned in.

In order to further fix the bandage in place, the nurse whips each fold of the bandage together *in front* and *on each side* with a needle and thread.

The Swans' Down or Five-tailed Traction Straps.

Swans' Down Adhesive has tissue-paper on the sticky side. As swans' down adhesive is much more expensive than ordinary surgeon's plaster, economy should be observed in cutting it. Usually it is about 16 inches wide and should be cut with shears into four strips four inches wide. This can be done accurately by ruling lines with a yard stick and the point of a pair of shears on the tissue-paper. In making a pair of strips, which are to be of the "five-tailed" variety, the length of the leg is measured from the anterior spine to the internal malleolus and this length cut off one of the four-inch wide strips. One inch is measured off from the corner on one end and one inch from the diagonally opposite corner on the other end. These two points have a diagonal line ruled on the tissue to insure accuracy. It is then divided into two with shears. Thus, we have two straps each of the desired length and one inch wide at one end and three inches wide at the other. Ten inches of webbing is now sewed to the adhesive, which now has the tissue peeled off it. In summer it sometimes happens the tissue is so adherent it cannot be peeled off whole, but comes off piece-meal and then with difficulty, so that it has even to be moistened with cold water on a gauze sponge to be removed entirely. When this is done a ¼-inch strip is cut down the length from the wide end to the point of junction of the webbing and adhesive on each side. Measurement is then made from two inches above the malleoli to the middle of the knee and this marked from the webbing to an equal distance up on the strap. From the wide end another ¼-inch strip is now cut on each side to the indicated point. We now have a five-tailed adhesive strap with a central portion 2 wide and two strips on each side, each a ¼ inch wide; two of these ¼-inch strips extend from just above the malleoli on each side to the top and two from the knee up on each side. These ¼-inch strips are to be the spirals. It is desirable to have the tissue-paper on as long as possible, as it renders cutting with shears easier and prevents the adhesive material from drying out and cracking (Fig. 29).

In application one strap is taken and its central strip applied vertically to one side of the *lower leg first*, so that the point of junction of the adhesive and webbing is two inches above the malleolus and the warmth of *both* hands applied to make it adhere to the skin. (It is a mistake to warm this adhesive on a radiator or before a fire, as it permanently softens the adhesive material too

much and makes the strap later slip when weight is applied.) Then the central strip of the other strap is similarly applied to the other side of the leg. When both are adherent, the skin and subcutaneous tissues on one side of the thigh are pulled down and the central strip similarly on both sides is made to adhere to the thigh.

If this technique is not followed, the junction of the webbing and adhesive will be, most probably, at different heights above the malleoli and the pull will be greater on one side of the leg than the other when weight is applied, resulting in discomfort to the patient.

Next, beginning at the bottom, the anterior ¼-inch spirals are wound around *without tension*, being directed at an angle of 45° all the way to the top and then the corresponding posterior ¼-inch spirals. Next, the anterior ¼-inch spirals at the knees are applied upward and finally the posterior ¼-inch spirals at the knee. During all this, the heat of the hand must be depended on to get the adhesive to stick firmly and smoothly to the skin and the application is greatly facilitated by having the aid of another pair of hands, such as those of another patient, who is desirous of being helpful. A "turned-in" gauze bandage is applied and stitched as previously described under the "two-tailed traction straps" and completes the dressing. No weight should be applied for four or five hours to insure the adhesive becoming thoroughly adherent to the skin.



FIG. 30.—Stocking extension.

A leather punch and two or three strong paper clips may be used to fasten the webbing to the adhesive instead of sewing and save time.

The "Stocking Extension."

This should probably preferably be called a "legging extension" as more properly describing what is meant, as it is a legging with lateral webbing to attach to a "spreader." A supply of these leggings made of twill cotton should be on hand in four or five sizes to fit different sized legs which can readily be made by the Hospital Seamstress or Ladies' Guild. They are made in two lateral halves stitched together at the back, from a paper pattern of the leg's profile.

Along the sides from the top down, a little anterior to the centre, are strips of webbing stitched extending 10 or 12 inches below the bottom of the legging. Under the stitched webbing at two-inch intervals are loops of strong tape, holding small brass rings projecting forward, through which lacing may be passed to hold the legging on. The application of this stocking extension is for acute cases, that is, those which require continuous traction to relieve pain and which for one reason or another, such as recently applied adhesives or those

whose skin has been broken and inflamed by adhesives, require steady, constant pull. The leggings should be made a little larger than the leg they are to go on, in order to permit dressing of the inflamed skin with gauze and a suitable ointment, such as a mixture of Boric and Zinc Oxide, and then covered with a layer of glazed cotton roll, until such time as it is advisable to re-apply adhesives. Or the stocking extension may be used over the completed dressing with adhesives until they are sufficiently adherent to permit the weight to be attached (Fig. 30).

The "Spreader."

The spreader is used to prevent the webbing from pressing against the sides of the malleoli or foot and the one devised by the author will be found convenient

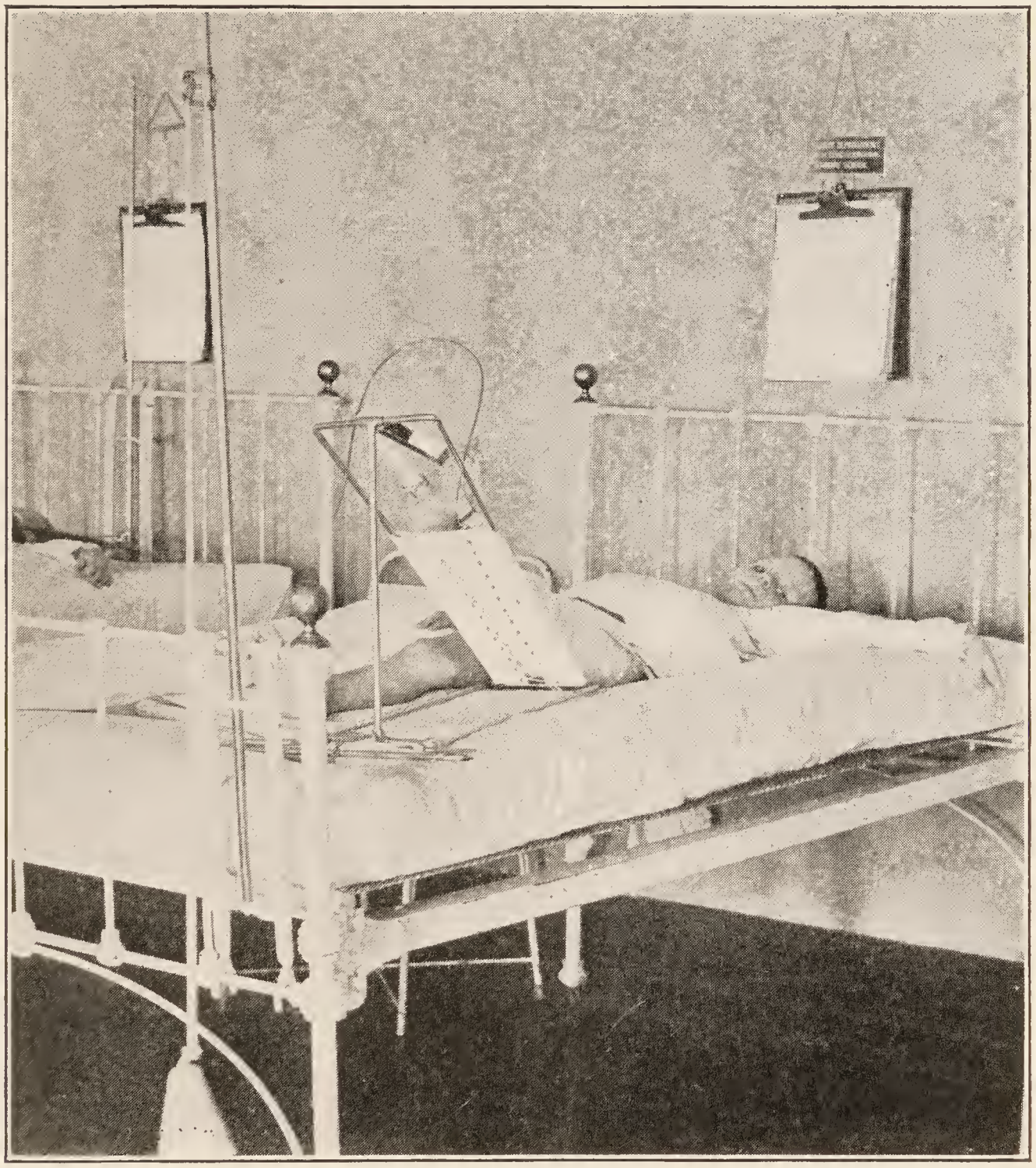


FIG. 31.—Inclined plane in acute coxalgia to accomplish "traction in the line of deformity." Fixation on Bradford frame. Pulley, traction rod and weight shown. Loop of wire on inclined plane to support bed clothes.

for examination of the degree of motion possible in a joint or other tests, when it is desired to detach the weight. This spreader consists of a piece of steel three to four inches long curved at right angles at the ends in which screws hold loops of steel containing ¾-inch buckles, into which the webbing

may be attached. In the centre of the steel rod is a loop on the opposite side from the buckles like a screw eye on the back of a picture frame, to which may be attached the small rope which passes over the pulley at the foot of the bed and to which the weight is attached (Fig. 31).

The "Single Tree."

In certain instances where traction has to be made on both legs and instead of having two-traction apparatus at the foot of the bed, a single tree may be used which consists of a bar of steel 12 to 15 inches long with a loop on each end and in the centre of the opposite side. The rope from each spreader may be tied to the end loops and the rope for the weight attached to the central loop.

Technique in Making Traction.

The painstaking nurse will cut the rope at a length which will bring the weights within two or three feet of the floor, so that with change of the patient's position, it will not be likely that the weight will rest on the floor. She will also wrap the end of the small rope with adhesive, string or cotton to prevent it fraying out or ravelling or unwinding, for tidiness sake. In tying the rope to the spreader and to the weight *one single* and *one loop knot* will be found to give a neat appearance and be a great convenience and time-saver if an additional weight is to be added or other change is to be made. Nothing is more untidy and reflects on the care in the surgical make-up of these cases than for a trained observer to go through a ward and see frayed out ropes, weights on the floor, spreaders in contact with the pulley and hard knots to be untied before a patient can be examined or a change made in the treatment. Slovenly applied traction straps and bandages and poorly maintained traction show very clearly one of two things, either an untrained orthopaedic nurse or a "slider."

CHAPTER V

SPINAL EXTENSION

Head Traction.

In certain spinal conditions or muscular contractures in the neck, it is necessary to affect recumbent traction on the head to relieve intra-vertebral pressure or deleterious or deforming spasmodic conditions.

The ailments most frequently calling for this treatment are tuberculosis, rachitic and traumatic spinal affections, as well as scoliosis and torticollis. Head traction is made possible by what is known as a "head-sling" consisting of twill-cotton and webbing. Two of these should be made for each patient to allow for washing, when one is soiled.

A piece of twill, double thickness, should be made to fit under the chin and a piece to fit under the occiput; these are joined by the webbing.

A pattern should be cut of the chin-piece in paper in the following manner: a square of paper four to six inches is folded in half, then in quarters; it is then cut down one of these quarter lines to the centre and these cut edges are overlapped more or less, depending on whether we have a pointed or rounded chin to fit (Fig. 32). It is tried on the patient fitted, by changing this lapping and pinned. It is next cut out to follow the carmine margin of the lower lip and similarly cut underneath to follow the forward curvature of the throat If thus fitted, it will stay in place and not slip down and cut into the throat and interfere with respiration. Allowance should be made in cutting the double thickness of twill for hems. A square piece is cut of suitable size (about three by three inches) in double thickness for an occipital piece also. When these two pieces have been basted, before final sewing machine stitching, a piece of ¾-inch webbing 24 to 36 inches long is centred and basted from its tip under the chin-piece to its upper corners. A nickel plated ring 1¼ inches in diameter is slipped over each end and the webbing turned over in an outward direction and then stitched into the upper corner of the occipital piece. On the sides of the chin-piece with teeth pointing backward in a direction under the ears are sewed two ¾-inch buckles so placed that the twill will not allow the buckle to come against the skin. Similarly, two pieces of ¾-inch webbing four to six inches long are sewed between the layers of the occipital piece, so placed that they are *at right angles* to the sides of the occipital piece and at the junction of its lower and lateral margin. When carried forward to the buckles this webbing will lie under, but not touch, the lower lobe of the ear. After being assembled and fitted the whole head-sling should be machine stitched (Fig. 32).

Another head-sling and simpler, but not as efficient, is a frontal and occipital band of webbing covered with canton flannel and with a buckle on one end.

On each side at right angles about eight inches of webbing is sewed to go upwards, just above the ears to the spreader.

Head-sling Spreader.

Head-sling spreaders should be made of steel or wood six to nine inches long and about $\frac{3}{16}$-inch thick with a loop in the centre for the weight rope and hook on each end opposite to catch in the metallic rings on the head-sling.

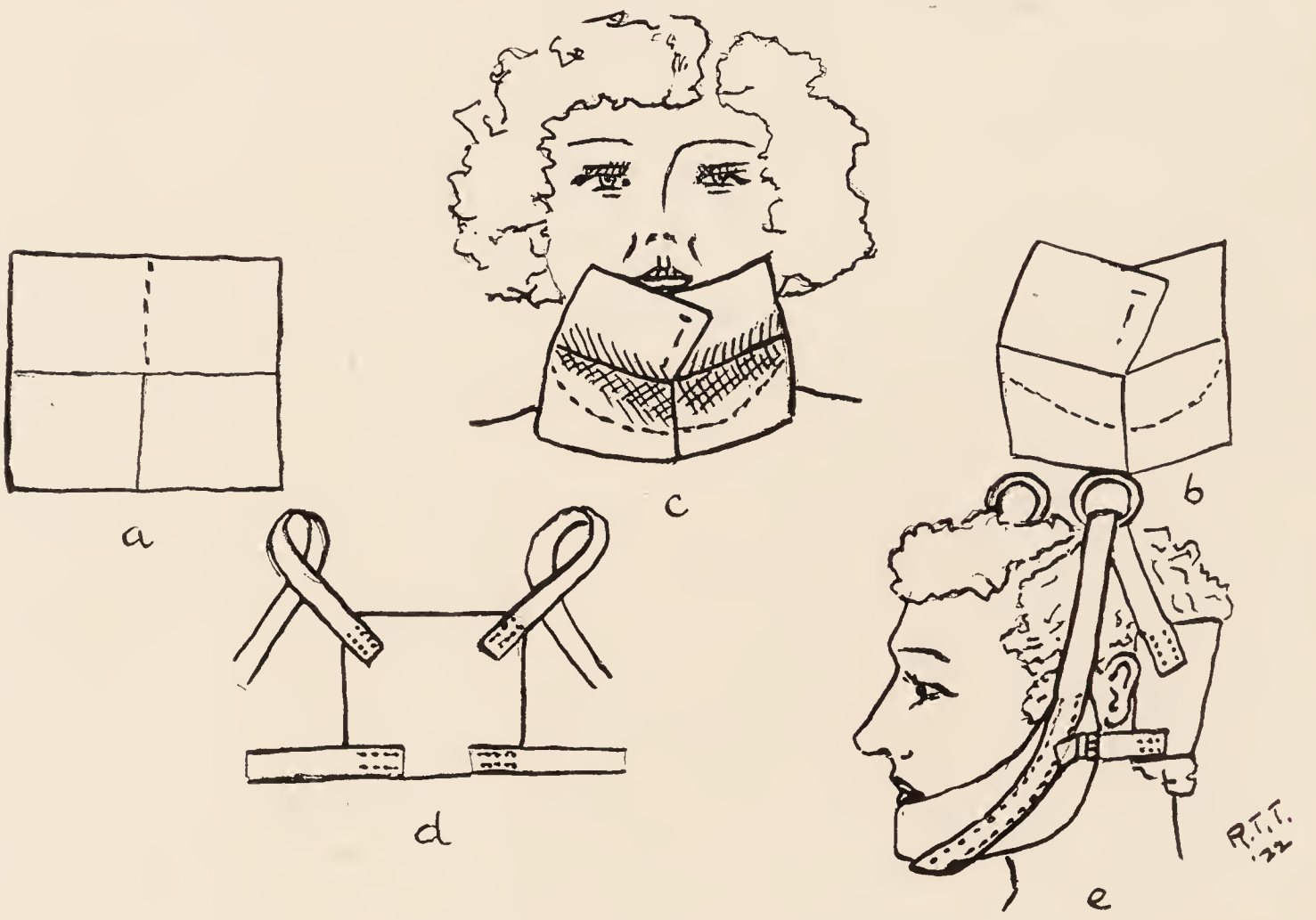


FIG. 32.—Diagrammatic details in making head sling.

a, Square of paper pattern folded in quarters; *b*, cut down (dotted line) one quarter and pin; *c*, fit and pin to fit point of chin. Cut out underneath dotted line in centre to avoid pressure on throat; *d*, square for back of head. Direction for sewing webbing.

Technique in Head Traction.

Care should be observed by the nurse that the head-sling spreader does not come in contact with the pulley at the head of the bed on the traction rod and thus vitiate the effect of the weight's pulling. She should also see that the chin-piece does not slip off the *front* of the chin, back against the throat and thus interfere with respiration. In acute upper spinal cases, where pain without traction is a marked symptom and in fact in all cases, the nurse should inquire of the attending surgeon whether he desires the weight lifted or the head-sling removed at meal-time or when the patient is "made-up," and the treatment suspended at this time. Of course, during eating there is great likelihood of the chin-piece becoming soiled and unless the nature of the case precludes, the attending surgeon will permit the unfastening of the chin-piece on one side and turning it out of the way, but in no instance probably will he allow the patient to assume a sitting position and recumbency must be maintained. No pillow or only a very flat or insignificant "baby-pillow" is permissible in these cases, under the head.

CHAPTER VI

TRACTION APPARATUS

Traction Rod, Pulley and Bed Attachment.

The author's traction rods are three to four feet long, made of ½-inch rounded steel and having a simple brass pulley sliding on it controlled by a thumb-screw, so that the pulley may be set at two or more inches or several feet above the mattress, depending on the angle in which the surgeon desires traction to be made (Fig. 33).

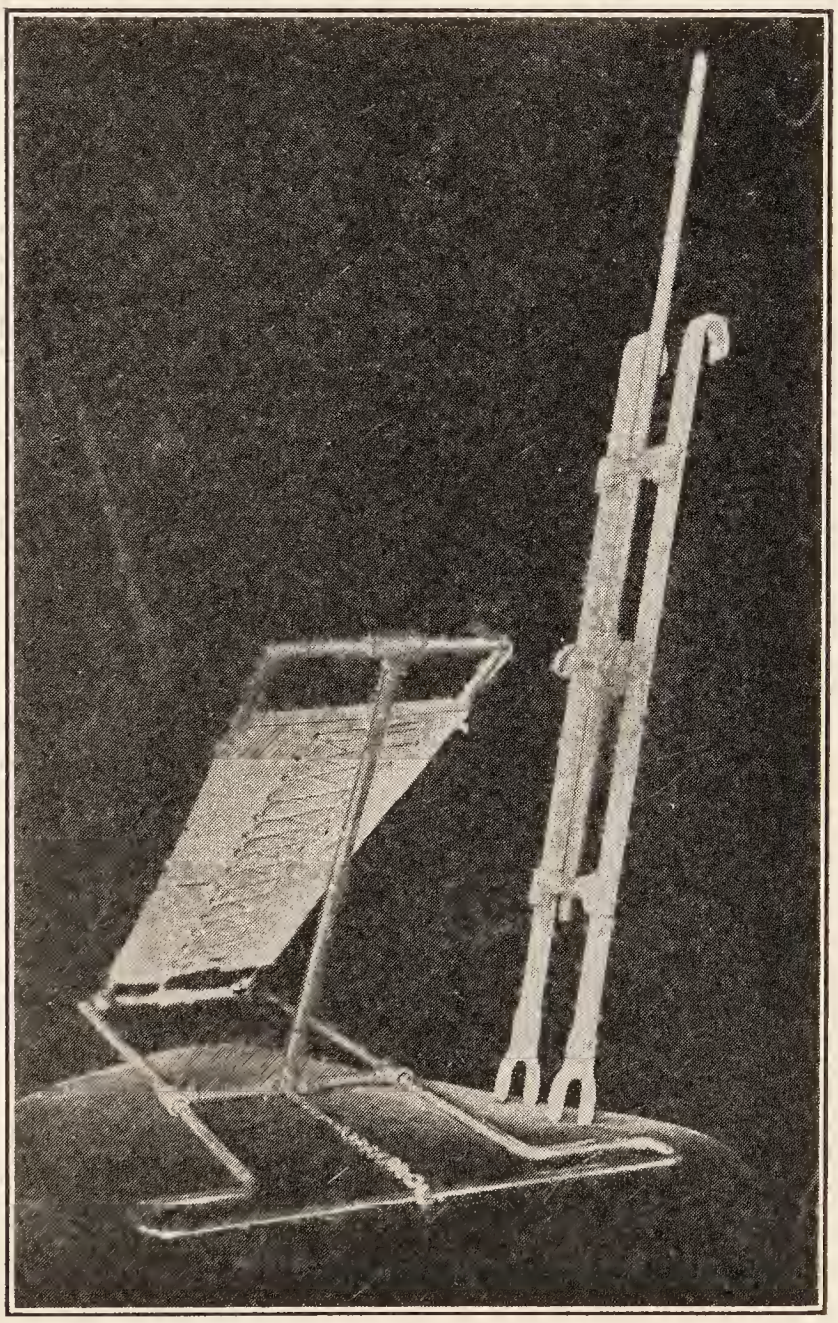


FIG. 33.—Author's traction rod, pulley and inclined plane.

The bed attachment consists of two flat (one-inch by three-sixteenths) strap steels hooked at the top to catch over the top of the head- or the foot-board of the bed and joined together by steel strips to allow the passage of the traction rod. These strips are twisted at the centre permitting the vertical passage of the rod through a round hole above and into a square hole below into which the squared end of the traction rod sets.

Caution should be observed by the nurse that the pulley does not twist, as is sometimes the case with heavy weights, on the traction rod, but so that the groove of the pulley is maintained in the line of the rope and not at an angle to it, which of course would block the proper pull.

Weights for Traction.

Weights for traction are usually made of lead poured into clay molds being somewhat the shape of an inverted flower-pot into the end of which a bit of steel wire is placed to allow of attachment of the rope. Except for little babies, five-pound weights will be found the most convenient size and can be multiplied as the discretion of the surgeon may prompt. The ordinary hook with pound weights removable, such as can be found on scales, may be had or shot or sand bags may be employed. (Fig. 31).

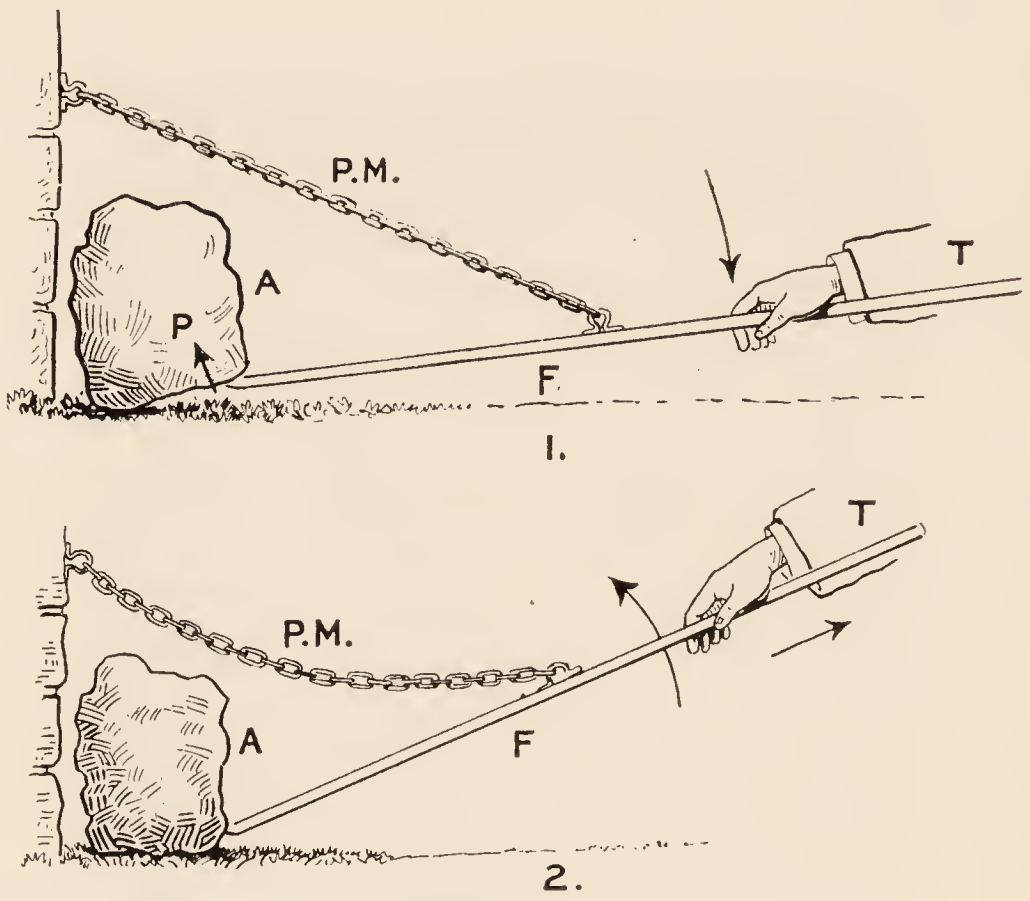


FIG. 34.—Diagrammatic mechanical explanation of "Traction in the line of deformity" in Coxalgia:

1. Result is *increased* pressure from traction in plane of bed with femur flexed by muscle spasm. *P.M.* = Tense Psoas Magnus. *F* = Femur. *A* = Acetabulum. *T* = Traction force; note direction. *P* = Point of pressure. 2. Traction in line of deformity. *P.M.* = Psoas Magnus relaxed. Acetabulum pressure nil.

If a child undergoing treatment by traction, cries out in its sleep, or in pain, it will often be found that something is awry with the traction technique or too much or too little weight is being used and a report of this should be made to the surgeon.

The Inclined Plane.

Muscular contracture from certain diseases, notably tuberculosis of the spine or hip, causes flexion of the thigh on the body and to relieve this contracture and malposition, lest it becomes a permanent disability and deformity, it is necessary to make traction on these limbs "*in line of the deformity*," as it is called, or what we may better express in such a position that the contracting

muscle is relaxed and not under tension. This is especially important in tubercular hip disease in which the muscular contraction, which nature offers as an effort to keep the parts from moving and causing pain, actually causes increased pressure between the softened, inflamed and infected bones that make up the joint and intensifies and promotes extension of the disease. It is our duty, therefore, to lessen this "intra-articular pressure," as it is called, by *distraction*, so far as we can, and allow the opposing surfaces to heal and overcome the deleterious muscular spasm. If we compare the offending muscle to a chain made fast in the side of a wall and the other end being fast to the centre of a crow-bar, the lower end of which is in contact with a stone, if we bear down on the free end of the crow-bar we will increase the tension on the chain and the pressure against the stone (Fig. 34). So it is in treating flexion of the thigh on the body or at the hip. We must relax the muscle and then make traction "in the line of the deformity" by raising our pulley on the traction rod to the proper height and support the leg on what is known as the "inclined plane" which can be adjusted to any desired angle.

The author's inclined plane consists of two hinged quadrilateral frames of ¼-inch rounded steel a few inches longer and wider than the leg it is to support. The upper frame is covered by twill muslin or canvas, which laces under the frame. A sliding rod is attached from the upper frame to the lower and is held in the desired position by a small chain. In emergencies or for low angles a pillow or folded sheet may be used, but the inclined plane is a more accurate and stable support. The steel frame and muslin inclined plane can be sterilized in event of infectious diseases (Figs. 31 and 33).

In fixing the bed covers and having them pinned with safetypins closely below the foot of the inclined plane to keep cold air from getting in at the foot of the bed, the nurse will see to it, that they do not interfere with the free pull of the traction rope.

CHAPTER VII

FIXATION IN BED

The Bradford Frame.

Many forms of fixation apparatus have been devised for the recumbent patient in order to maintain a definite position of the body with relation to the legs or arms, or immobilization of the body, but none of them have equaled the Bradford Bed Frame for efficiency and cleanliness, devised by Doctor E. H. Bradford, of Boston.

This frame consists of a rectangular quadrangle of ½-inch gas pipe and elbows covered with canvas, which laces on its under surface, the upper surface being taut and smooth and upon which the patient's body rests (Fig. 35).

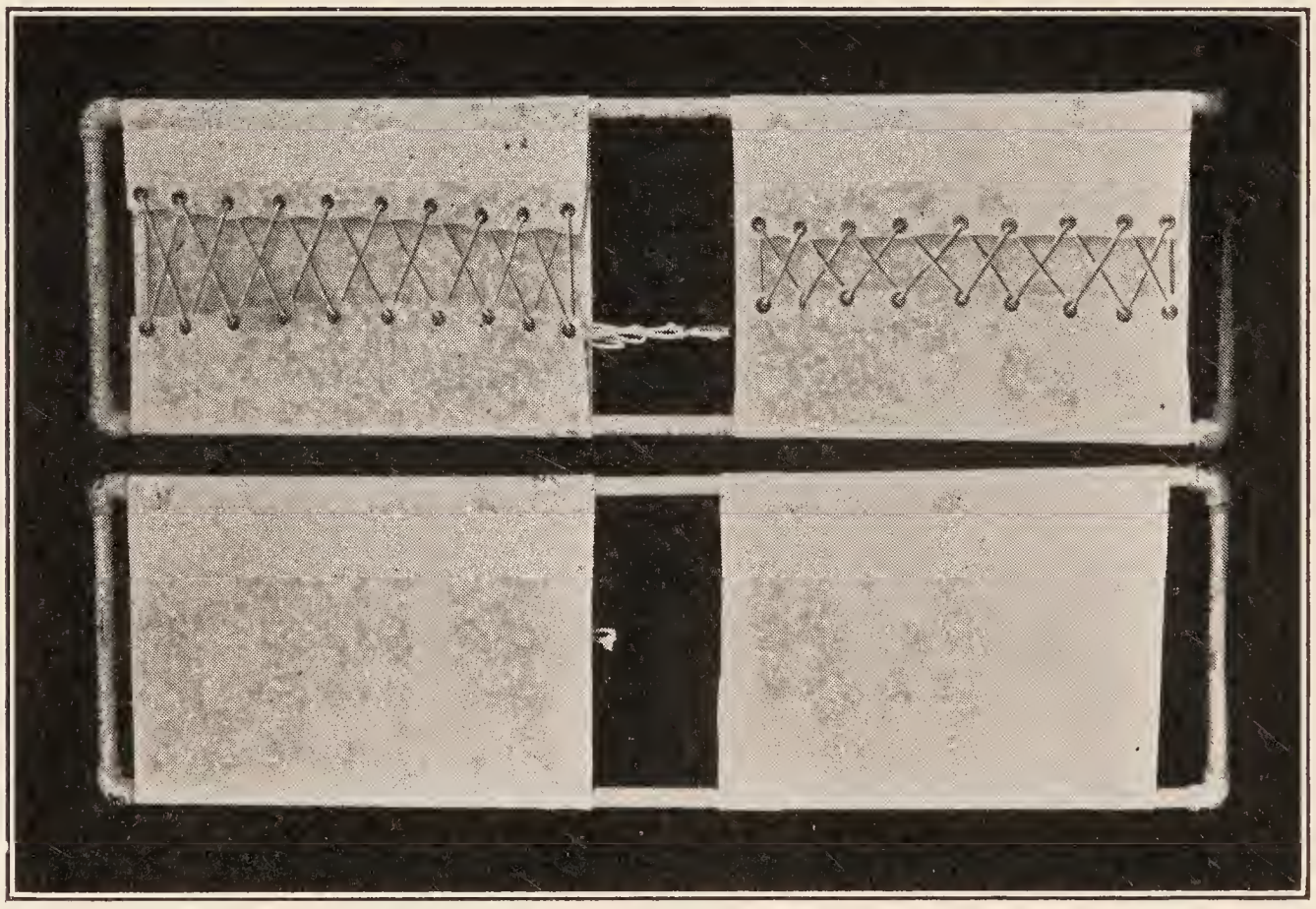


FIG. 35.—Bradford bed frame.

In patients, especially children, who will not stay in a definite position on the frame or who require fastening to the frame, it is essential that the frame fit the patient; any straps going around the frame and patient, if a frame is too large, will permit the patient to twist or turn on the frame and thus defeat the object of treatment; on the other hand a frame too small will be uncomfortable, as it will require portions of the patient's body to rest upon the gas pipe frame. It is therefore essential to have a frame that fits the patient and, in order to get this, four inches must be added to the height of the patient and two inches to the breadth of the patient's shoulders, if efficiency is to be obtained.

Several methods of fastening the patient to the frame have been suggested, the simplest being the military-cross-strap of webbing, which is passed under the frame and patient in the region of the patient's neck; then the ends are crossed over the patient's chest, pass under the frame and then pass over the patient's pelvis and are joined, one end being supplied with a buckle. If a patient is apt to undo this strap, in order to sit up or assume a detrimental position, the buckle and free end may be so placed as to be under the frame and preclude the possibility of the patient reaching it or getting at it to loosen it.

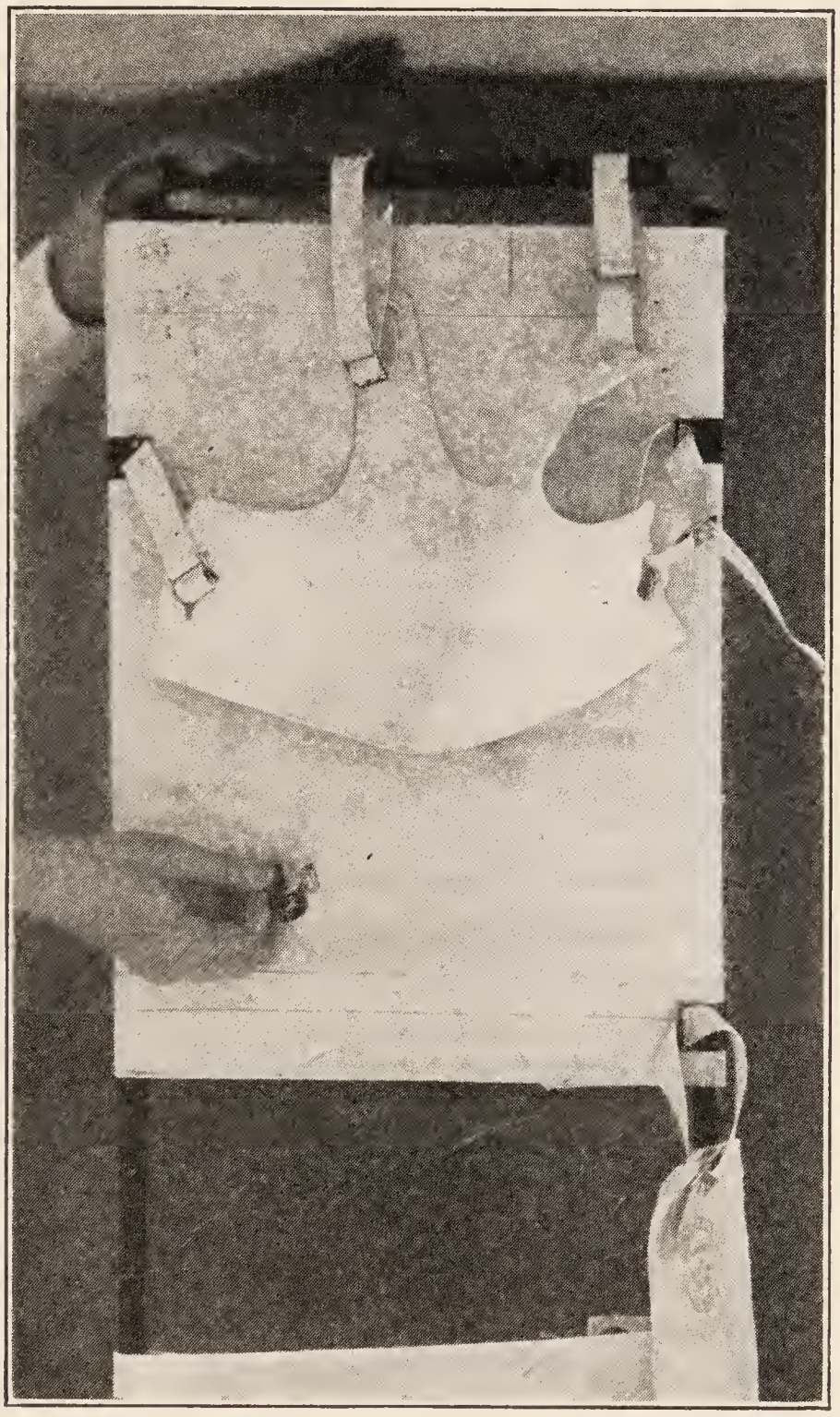


FIG. 36.—Author's spring clips, bibs and pelvic piece.

Special light canvas bibs and pelvic bands and spring-steel clips such as devised by the author, will be found more advantageous and efficient in thorough fixation. The bib fits the upper part of the shoulders and chest down to the intercostal notch, being cut out at the neck and in the armpits and has a button hole at the top and on each side to allow webbing straps to pass through them and the spring-steel clips, which are sprung on the frame and canvas cover at any desired point. One end of each strap has a buckle. (Fig. 36).

The pelvic band is about three inches wide and the width of the pelvis long and has a button hole for straps similarly on each side.

When a child endeavors to loosen itself, it must therefore undo at least three or four buckles before detection. The spring-steel clips are made by John D. McGonigle and Company of Baltimore (Fig. 36).

The canvas cover to the Bradford Frame is so made that a moderate gap is left on the under surface, along the length of which on each side are inserted strong eyelets through which a heavy twist cord is passed to insure lacing it taut and affording a smooth comfortable surface for the patient. In certain cases where we are dealing with acute and painful inflammations of the spine or hip or fractures and it is essential to move the whole individual en bloc, as for example in changing the sheets on the bed or placing a bed-pan *under the patient and frame*, it is desirable to have the canvas cover made in two parts, an upper cover extending from the top of the head to the tuberosities of the ischia, then an interval of four inches is left vacant and from this point to the bottom of the frame the lower frame-cover is fitted. In measuring for the width of the frame-covers, a safe method is to have them one and three-quarters the width of the frame. The eyelets should be about a ¼ of an inch in diameter and of brass preferably, put in by sail- or awning-makers, as they are much more durable than the small eyelets used by shoe-makers, and should be along each side of the length of the cover. When a patient has incontinence of the bladder or bowels from paralysis or other cause, the Bradford Bed Frame with the divided cover and opening coming just below the ischial tuberosities will be found indispensable in keeping the bed dry and clean, especially if the Bradford Frame has legs at each corner, from three-way elbows, or is supported at top and bottom with a two by four piece of wood, which may be covered for appearances with a piece of old sheeting or planed smooth and painted with white enamel to match the hospital bed and frame. This elevation of the Bradford Frame will permit keeping a bed-pan constantly under the patient. In other cases not so bad, but in which it is desirable to maintain as far as possible the immobility of the spine or hip and permit occasional use of the bed-pan, the Bradford Frame may be lifted at the bottom and the bed-pan slipped *under the frame and patient* and placed at the frame-cover opening.

Hyper-extension.

In tuberculosis of the spine, the spine flexes forward above and below the point of disease and the spinous processes project backward leading to the deformity of hump-back. It is essential during the early treatment of these cases that a pad or block be placed on the Bradford Frame under the projecting hump to push forward and to produce "*Hyper-extension*" at this point and allow the forward flexed portion to sag downward and backward by gravity and thus *flatten the back* as a whole. Manifestly if one of these correcting pads slips up or down and presses against the forward projecting segment of the spine, it will do harm rather than good and it should be the *especial duty* of the careful orthopaedic nurse to see to it that no such harmful displacement occurs. These pads, to secure this hyper-extension at the point of disease in tuberculosis of the spine are made of various materials; the simplest small pad is made of a folded towel, napkin or sheet; some surgeons employ a strip of felt two inches wide and

an inch or more thick stitched to the undershirt at the proper place or fastened to the skin with adhesive and in other very acute and severe cases, wooden convex blocks are especially made by the hospital carpenter or resident surgeon, grooved in the centre in order not to press unduly on the unusually prominent spinous processes and covered with felt; these blocks are usually the width and length of the body and produce backward extension or hyper-extension of the whole spine, especially so shaped as to have this at its maximum at the point of disease (Fig. 26). This hyper-extension is effected by Doctor Royal Whitman by having the gas pipe frame bent with pipe wrenches into an upward convex arc. Still other surgeons in very acute cases use a plaster of paris jacket or shell, i.e., half a jacket, made when the patient is held by appropriate apparatus in the maximum obtainable hyper-extension at the point of disease (Fig. 37) and then kept recumbent as well on the Bradford Frame. Some place

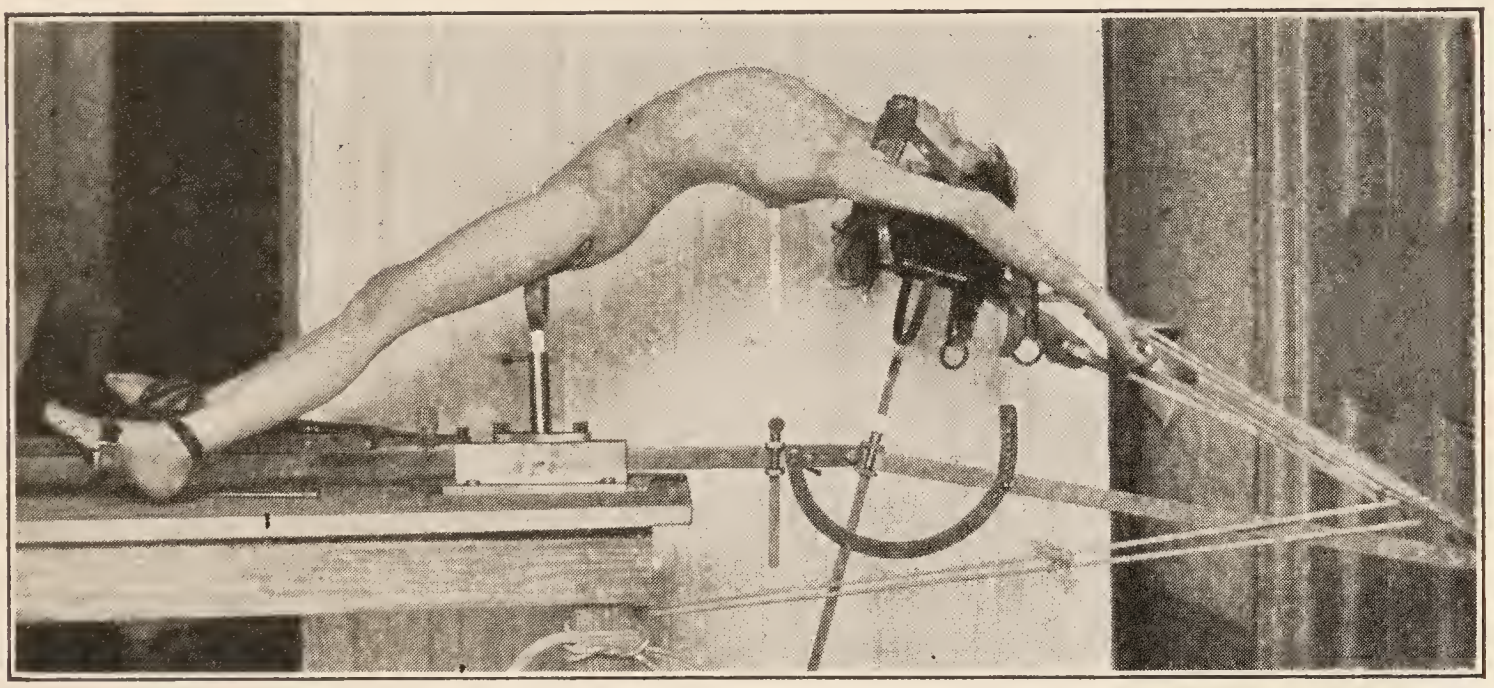


FIG. 37.—Author's large recumbent kyphotone with head and leg traction and hyperextension rod used in Dorsal Pott's disease for applying plaster jackets.

the patient on the bed frame on the abdomen and have a plaster half shell to support the chin and thorax so that hyper-extension is thus maintained in lumbar disease. Still other acute cases require the use of a specially fitted steel-backbrace as well as the Bradford Frame to secure the most efficient immobilization and treatment in recumbency (See Pott's Disease).

In tuberculosis of the spine or hip joint, in certain fractures and dislocations of the hip or in contractures due to paralysis causing distortions or deformities, it is essential, in order to cure, that the body be efficiently fixed on a bed frame, so that traction by means of Buck's Extension, and possibly with the use of an inclined plane also, may be made on the leg in *a certain habitual continuous definite direction* of abduction, flexion, adduction or extension. The Bradford Bed Frame is found to be invaluable for these cases requiring fixation (Fig. 26).

Blocks for Raising Head or Foot of Bed.

Occasionally, when the traction weights are moderately or quite heavy, it will be found in leg traction that the patient is pulled down in bed, so that the foot spreaders touch the pulley and vitiate the traction treatment. In such

cases blocks six inches high are placed under the rollers at the foot of the bed, depressions being made with a brace and bit to permit stability of the rollers. The nicest of these supports are truncated cones turned at a saw-mill, being six inches high, 2½ inches in diameter at the top with rounded margin to hold the roller of the bed and 3½ inches in diameter at the bottom.

By means of the blocks and the elevation of the foot of the bed "counter-traction" or "counter-extension" is effected by the weight of the body.

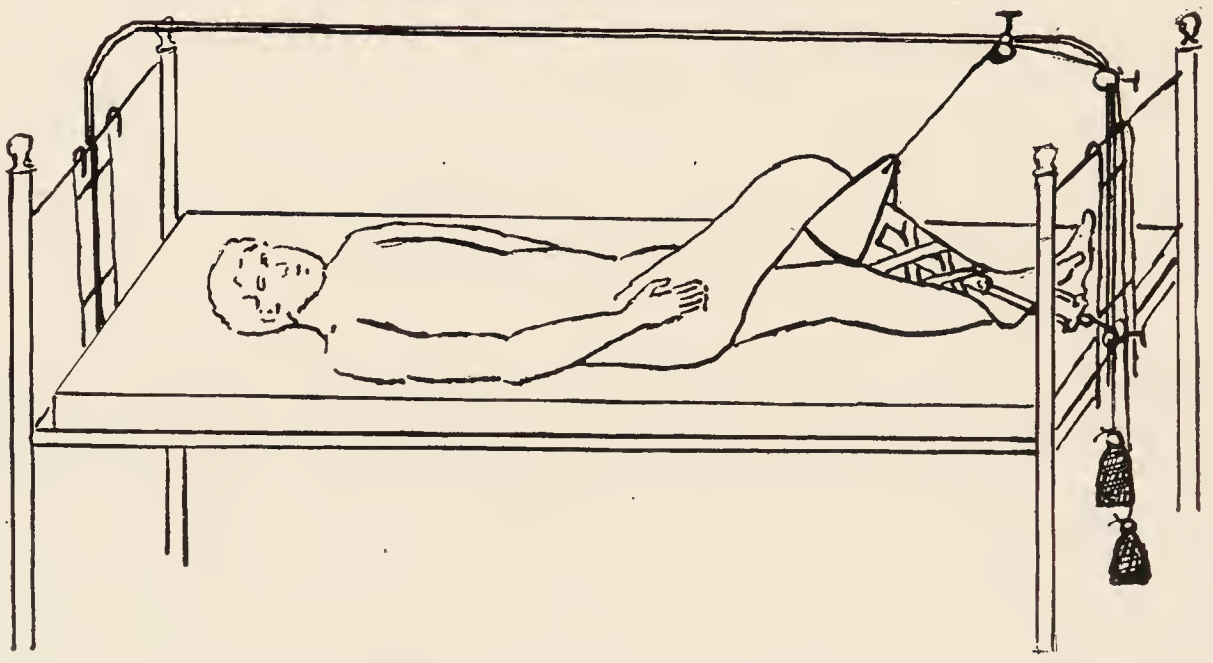


FIG. 38.—Author's knee two-way traction apparatus.

Similarly in head traction it is sometimes necessary to raise the head of the bed by these blocks to effect counter-extension by body weight.

In certain instances where the spinal symptoms in tuberculosis or other ailments are so acute that traction is necessary on both the head and lower extremities, no blocks are required under the bed legs as one kind of traction off-sets or balances the other.

In certain cases it is necessary to make traction in two directions as in Tuberculosis of the knee (Fig. 38).

CHAPTER VIII

SUPPORTING AND TRACTION APPARATUS*

The Balkan Frame.

As a product in the Balkan War and the Great War in the treatment of compound fractures chiefly, the Balkan Frame was developed and popularized chiefly by Doctor Joseph A. Blake of New York, while in France.

The awkwardness of plaster casts with windows or metal splints to produce *fixation* was superseded by the more accurate and scientific method of *suspension and traction*, which permitted of ready access to the wound for dressing and infiltration with Dakin Solution or the Gallie-Taylor method of wound distension and syphonage by salt solution and at the same time permitted the patient to change his position in bed at will, left the joints above and below the fracture mobile and at the same time maintained the alignment of the fragments of the fracture. Such an arrangement, it can readily be seen, promoted in a high degree the maintenance of the circulation and joint function and lessened oedema, which all methods of fixation must of necessity interfere with. The natural healing value of an unimpaired blood stream or aided circulation will readily be appreciated by a thoughtful observer.

As a rule in nearly all fractures owing to muscular contracture or muscle spasm the *proximal* fragment is pulled in an abnormal direction or position and the distal fragment either assumes an abnormal angle with the former or over-rides it, or both conditions occur, from an abnormal muscular pull and gravity. Of course, the upper fragment bears a more or less fixed relation to the body, while the distal fragment is movable. It is therefore up to the surgeon to apply a suspension sling or support to the *distal fragment, so that it will be* in alignment with the proximal portion and that is the sine qua non to success in the fracture problem. We must, however, add to this the necessity in many instances of overcoming over-riding of fragments from muscle spasm. Forcible manual or even instrumental efforts to get immediate end to end approximation of broken bones, under complete anaesthetic relaxation, may fail, while the result is amazingly rapid, exact and satisfactory often, after a few hours of *traction on the distal fragment in the line of the proximal fragment* by a comparatively light weight, which overcomes the muscle spasm and permits the remaining portions of periosteum and soft parts to marshal the broken bones into line. Exact reduction must in all cases be confirmed by a portable bed-side X-ray machine with fluoroscopic study or preferably radiograms for record in case of subsequent law suit, as well as to assure the surgeon of the accuracy of his work.

*Illustrations and much of text of this chapter are used through the courtesy of Dr. Joseph A. Blake and Surgery, Gynecology & Obstetrics.

With these physiological and mechanical aims in mind the description of the Balkan Frame may be more fully appreciated.

The Balkan Frame, as applied to hospital beds, rather suggests a mosquito canopy or the old fashioned tester beds or "four-posters" of our grandparents. In the top of this frame pulleys are fastened in varying positions to meet the need of allowing cords with weights to suspend the broken arms or legs by slings, in such fashion as to secure alignment of the fragments. It must also permit of application, to the head or foot or side of the bed, of pulleys to aid in traction, at any angle or adduction, abduction, flexion or rotation that may be desired.

The Apparatus.

To quote in extenso Doctor Blake ("The Treatment of Fractures of the Extremities by Means of Suspension and Traction," Surgery, Gynecology and

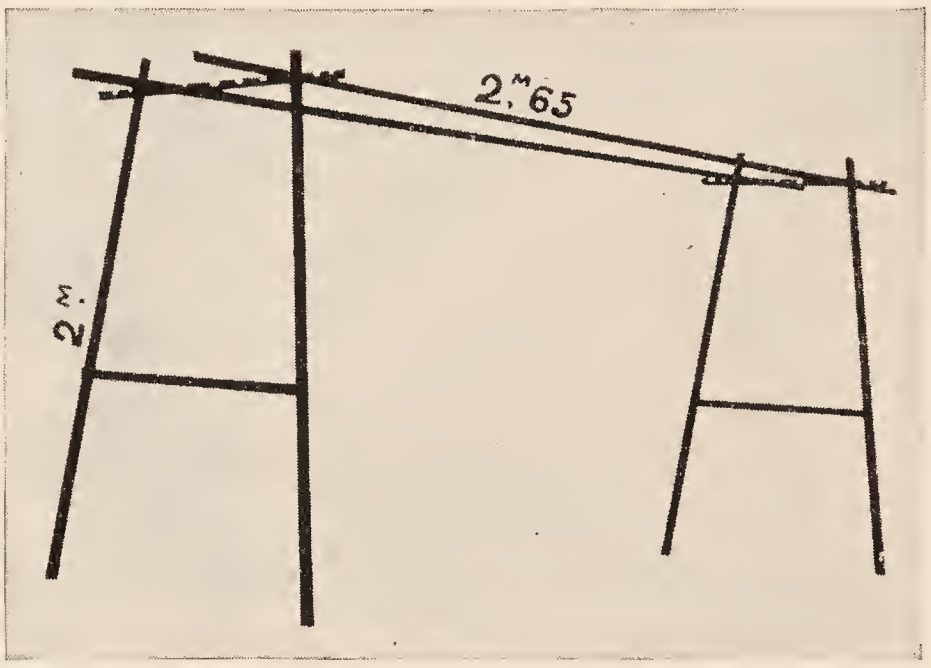


FIG. 39.—Illustrates the general arrangement of the frame not placed on the bed. The longitudinal bars can be shifted laterally to any of the notches in the upper transverse bar shown more clearly in Fig. 40.

Obstetrics, March, 1918): "The apparatus consists of two frames each fitted to an end of the bed, and connected above the bed by two or more parallel bars. Each frame consists of two uprights joined by two transverse bars, the lower placed at the upper level of the mattress and the upper just low enough so that the uprights are not split by the holding screws. The upper transverse bar is notched to hold the longitudinal bar, each upper transverse bar having nine such notches. Each longitudinal bar has two notches at a distance from each other corresponding to the distance between the two end frames. The interlocking of the grooves prevents slipping and gives solidity (Fig. 39).

"The end frames have the form of a truncated cone, base downward, the distance between the feet being a little more, and the distance between the upper ends being a little less than the width of the bed. The width, therefore, is an inconstant factor depending on the bed used. The height is generally two meters. With pine, which has proven to be a very satisfactory wood, we have found that pieces five cm. wide and 21 mm. thick are sufficiently strong for the vertical and lower transverse bars, and pieces six cm. wide for the upper transverse and longitudinal bars (Fig. 40).

In order to allow the patient to change his longitudinal position, as, for instance, to sit up in bed, suspension must be movable. This is true only for fractures of the lower extremity. For those of the upper extremity it has seemed unnecessary. This range of motion is accomplished by the use of a trolley consisting of a track and a movable piece of wood suspended from it. The track consists of a bar of iron, 10 mm. thick and about 90 cm. long, right angled at one end. The straight end passes through a hole in a small piece of iron bent to a right angle and screwed to one of the longitudinal bars. The angled end of the tract is fastened to the bar by a bandage. Suspended from this is a block of wood, about 40 cm. long, in the upper edge of which are screwed two pulleys to run on the track, and on the lower edge of

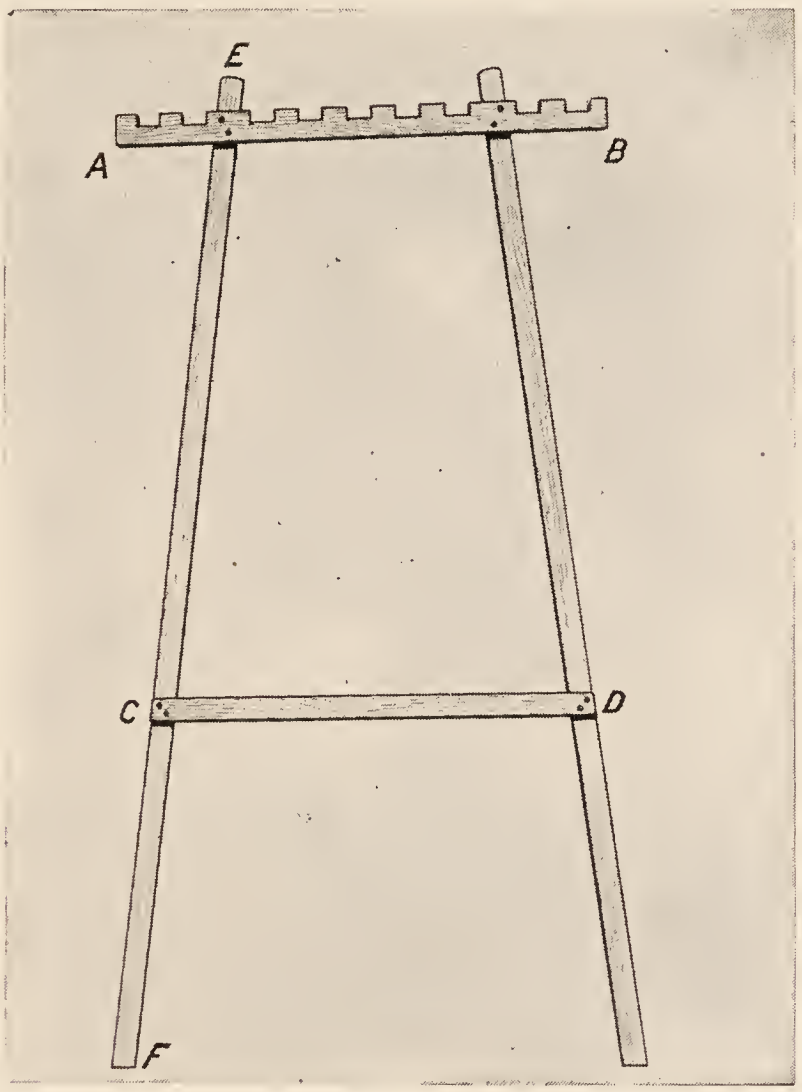


FIG. 40.—To show the details of construction of each end frame. The centre notch on the upper transverse bar is seldom used and tends to weaken the apparatus. It is better not cut. Each vertical measures 2 meters. The length of the transverse bars depends on the width of bed used. For the Service de Santé bed the upper bar measures 1 meter and the lower transverse bar 75 centimeters.

which are screwed three pulleys for suspension. Pulleys attached either by screws or hooks may be used. The latter seem more readily adjustable. The weights are commonly of 500 grams each. For more delicate adjustment, and especially where they are to be suspended over the bed, small shot bags varying in weight from 250 to 1000 grams are employed. The approximate weights used, it must be remembered, should be so adjusted as exactly to counterbalance the weight of the limb. Due to the decrease of oedema, they frequently have to be reduced after the first or second day (Fig. 41).

The limbs are suspended either by cloth bands or by metal splints to which cords are attached. The different forms will be described with the different fractures in which they are used.

For adhesive material we have used two different glues. (1) Heussner's glue (Colophane 50, 90 per cent. alcohol 50, Venetian turpentine 1, benzine 10) was formerly used in all cases and proved exceedingly satisfactory except for the occasional blistering which took place under it and for the necessity of shaving the part before application. After being applied to the shaved skin with a brush, the special extension bands of canton-flannel are laid on the extremity and bandaged in place. These bands are made in advance in two sizes, one for the leg and the other for the arm and sole of foot, and are provided at one end with a tape to fit the buckles of the apparatus. In using Heussner's glue, the skin

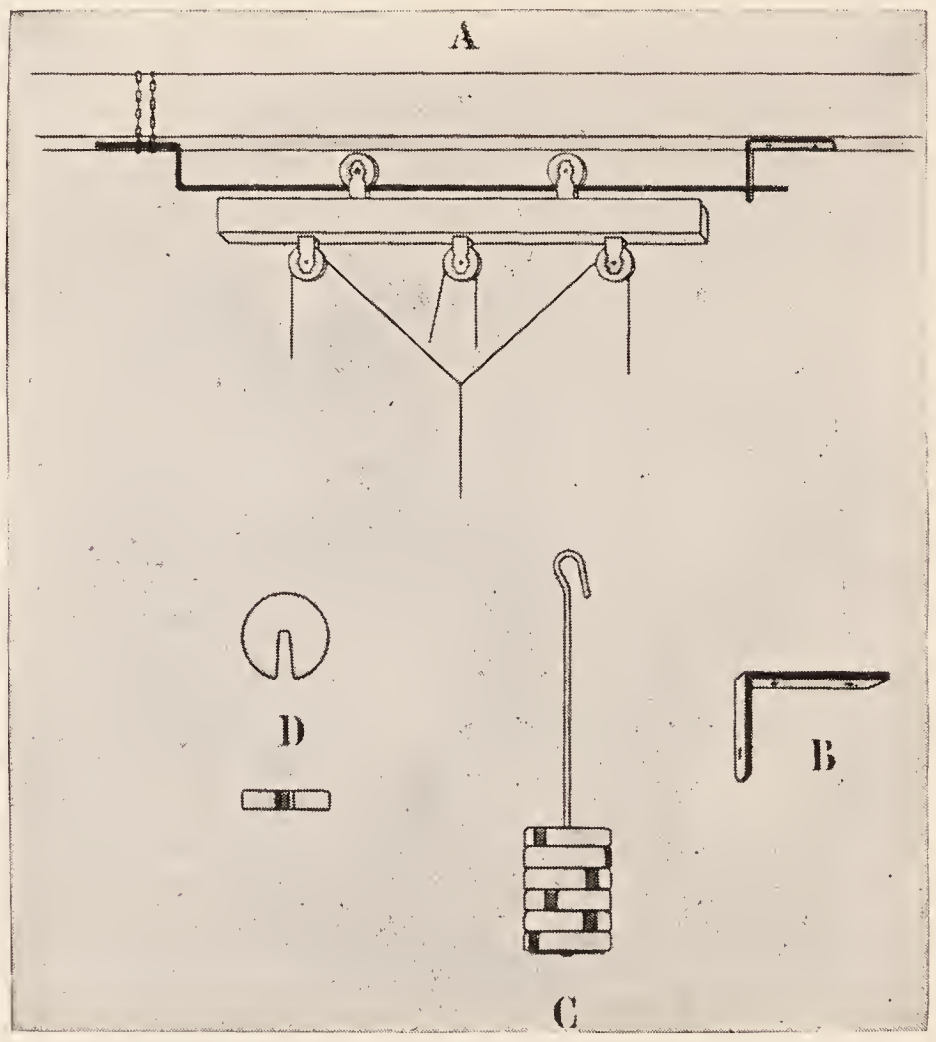


FIG. 41.—To show the arrangement of the trolley. In *A* can be seen the iron bar serving as a track and right angled at one end while the other end passed through a small piece of iron *B* screwed to a longitudinal bar. The wooden block with 2 pulleys above and three below hangs from this bar. *C* and *D* show the lead weights used, each weighing a half kilo.

should be prepared with soap and alcohol, but no antiseptic should be used. Absolute cleanliness and the removal of all grease is essential. More recently we have been employing the glue of Sinclair-Smith (2) common glue 50, water 50, glycerine 2, thymol 1, calcium chloride 1. Its chief advantages are that the part does not require shaving before application and that it can be removed by the application of hot moist towels. It should be painted on the skin hot in a direction opposite to that in which traction is to be made. This avoids the discomfort of pulling hairs. Blistering seems to take place a little less frequently with this watery glue than with the varnish glue of Heussner, possibly due to the greater ease of evaporation. With either glue the bands will usually hold for 10 days to three weeks before renewal becomes necessary (Figs. 42B and 43).

The traction can usually be applied about 20 minutes after the bands have been glued in place. The details of the method employed for fractures at various levels must be carefully studied for each individual case, as the lines of

fracture and the injuries to soft parts with the resulting displacement of fragments vary so greatly. Constant supervision and revision of position and weights is necessary, for only in this way can the best results be obtained. It is essential that each apparatus be daily examined and the alignment of fragments clinically noted. If the slightest doubt as to position occurs, a bedside fluoroscopic examination or roentgenograph should be made. As far as possible, we will attempt to indicate the treatment necessary for fractures of the extremities at various levels.

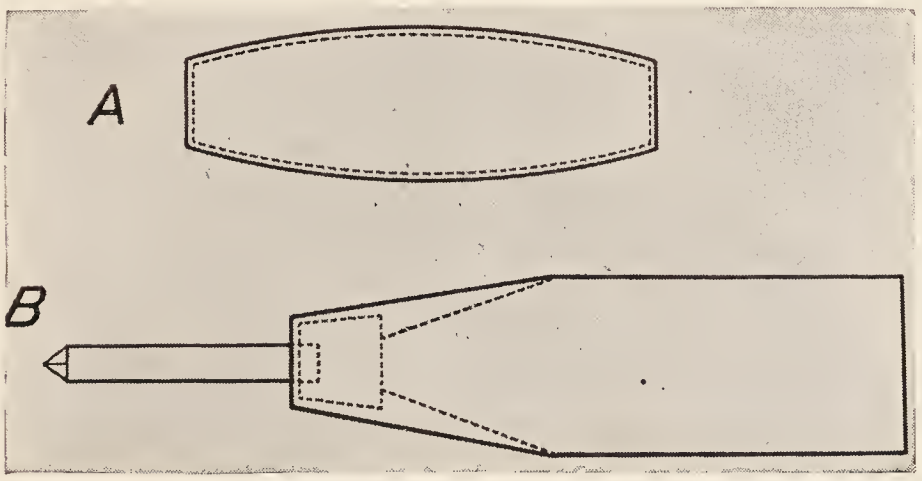


FIG. 42.—*A* shows the shape of the bands used to support the limb in a Hodgen or Blake splint or in a forearm cradle. They are made of 2 layers of unbleached muslin and in two sizes. The smaller measured 40 by 12 centimeters and the larger 60 by 20 centimeters. With wet dressings, bands of similar sizes but made of double faced rubberized linen can be used. *B* shows the bands used with glue for traction. They are made of canton flannel in a small size for the forearm and the sole of the foot and a large size for the leg. They measure without the tape 25 by 8 centimeters and 40 by 15 centimeters respectively.

Humerus—General Considerations.

Suspension is made at two points, direct suspension of the humerus itself and suspension of the forearm. The humerus is suspended by a single band of double-faced rubberized linen 26 cm. wide and 70 cm. long. The angulation they were designed to correct can be more easily controlled by traction, if used, and by the amount of suspension applied to the forearm. This single band passes under the arm and is attached at one end by thumb tacks to a block of wood. Its other end is pierced by eyelets which accurately fit small nails on the opposite side of the same block. In this way the band is not only prevented from becoming wrinkled, but it can be readily removed for dressings. To each end of this block is attached the extremity of a cord about 50 cm. long, from the centre of which is carried a second cord leading vertically upward from the centre of the humerus to a pulley in a longitudinal bar. The relative amount of suspension obtained at the proximal and distal ends of the band can be controlled by shifting the point of attachment of the vertical cord to the cord attached to the block and anchoring this point of attachment with adhesive. In general, 1½ kilos suffices for the direct suspension of the humerus (Figs. 43, 44 and 45).

The forearm is suspended by means of two bands glued on the flexor and extensor surfaces. They should not meet on the lateral aspects of the arm because of the constriction and interference with circulation which might follow. The tapes which are fastened to the ends of these bands are attached by buckles to a wooden spreader at the centre of which is a hole for a knotted cord for sus-

pension. The spreader for the hand should be a little longer than the width of the fist and three-quarters as wide as its length. The straps of the suspension band pass over the side of the spreader, while to the ends of the spreader are fixed two elastic tapes attached to a round handle which can be adjusted so that the fingers can readily grasp is for exercise. This arrangement is of importance,

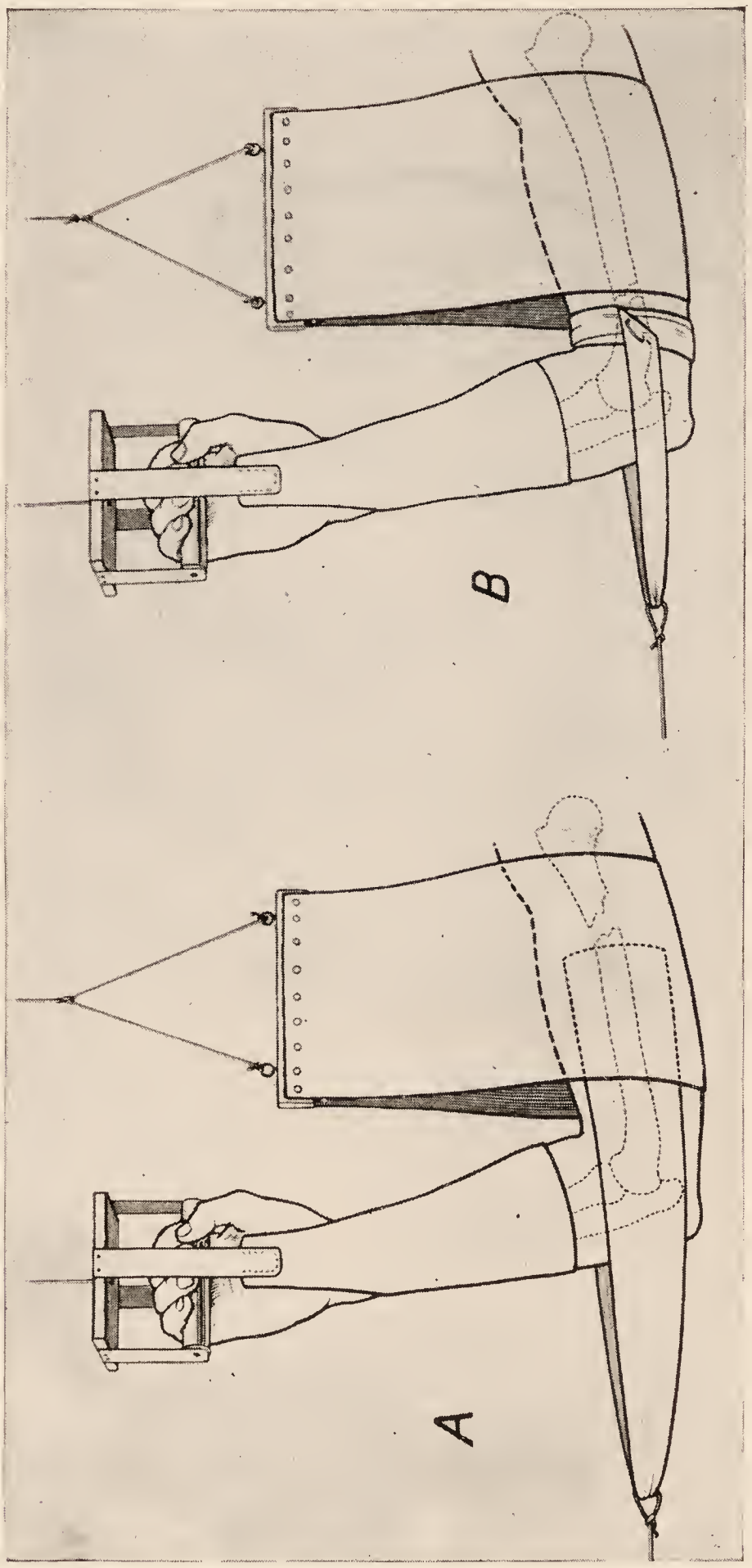


FIG. 43.—Both figures illustrate the general method of suspension and extension in fractures of the humerus. *A* illustrates a high fracture in which traction by glued bands can be obtained. The drawing is incorrect in that no wooden spreader separates the bands. The arrangement of the humerus are shown. *B* represents a lower fracture where glued bands cannot be employed. Here the Hennequin band is used. It will be noted that the axis of the humeral shaft and the axis of traction are the same and that this is accomplished by the safety pin holding the band on each lateral aspect of the arm. The detail of the hand spreader can be better seen in Fig. 46.

especially in lesions of the musculospiral nerve. The suspension cord passes to a pulley on a longitudinal bar above the bed, this bar being placed 20 or more centimeters to the outer side of the bar by which the humerus is suspended. In this way external rotation of the lower fragment is obtained, a result difficult to get if both humerus and forearm are suspended in the same longitudinal axis.

The pulley suspending the forearm is usually placed sufficiently toward the foot of the bed to keep the elbow at an angle of about 135° extension. Later the angle may be decreased to 90°, but the larger angle, if used early, assists in traction (Fig. 46).

If traction is necessary, it can be obtained in one of two ways. Traction on the lower fragment by means of glued bands on each lateral aspect is very efficient. The spreader for traction of the arm should exceed the width of the elbow by two cm. to avoid pressure on the humeral epicondyles. Traction is made from the spreader by means of a cord which passes over a pulley in a

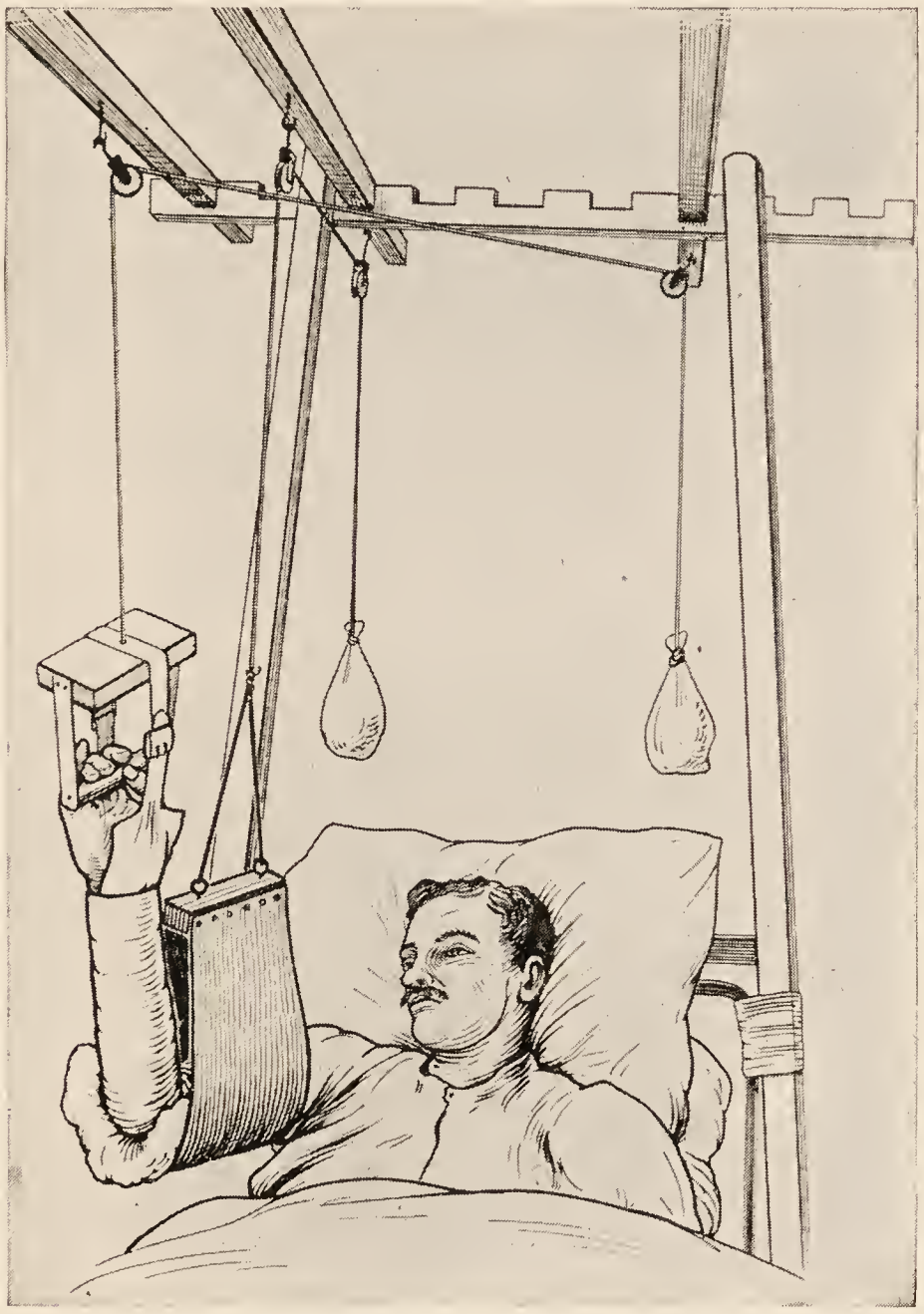


FIG. 44.—To illustrate the method of suspension in fracture of the humerus. It is to be noted that three longitudinal bars are employed, the outermost serving to support the forearm and maintain outward rotation of the lower fragment (see text under "Humerus, general considerations").

transverse bar attached at a suitable height to the frame at the foot of the bed. If the wound in the arm is in such a position that glued bands cannot be applied, traction can be obtained by means of a band passed about the lower humerus in much the same way as in the method of Hennequin in fractures of the femur. This band is made of heavy muslin, about six cm. in width and one meter in length. Its centre is placed on the posterior surface of the lower arm, each end being brought forward and crossing to the opposite side where it is pinned in such a way that the traction, when applied, will be in the same axis as that of the humeral shaft. In low wounds of the arm, a thick layer of cotton should be

placed between the dressing and the band. Counter traction by the weight of the body is sufficient for fractures of the humerus.

In all fractures of the humerus treated by this method the patient should be encouraged to move the shoulder, elbow, wrist and fingers and the hand and fingers should receive daily massage. The question of the amount of abduction will be considered with the detailed treatment of the fractures at different levels.

We will consider the modifications of the above outlined treatment as they apply to fractures at various levels of the humerus under three heads: (1) fractures of the upper third, including resections of the humeral head, (2) fractures of the middle third, and (3) fractures of the lower third, including resections of the elbow.



FIG. 45.—To illustrate a simple method of obtaining abduction and traction by means of a rough board slipped between mattress and bedspring and holding by friction (see text, "Humerus, upper third"). Spreader distal to elbow was also omitted here by the artist.

Humerus, Upper Third, Including Resections of the Humeral Head.—Cases falling in this group should all be suspended as above outlined. Following humeral head resections, traction should not be used. The deltoid should not be stretched, but rather allowed to crowd the divided shaft as closely as possible into the glenoid. Loss of function of the circumflex nerve or extensive loss of substance of the deltoid means a poor end-result following resection. The arm should be abducted nearly to a right angle in order that this position after healing can be assumed by the patient. Adduction can always be obtained by rotation of the scapula.

In high fractures of the surgical neck, the upper fragment is usually abducted and strongly rotated outward. The lower fragment must, therefore, be brought into this position. The frame at the head of the bed must be somewhat modified to meet the unusual requirements. The amount of traction in such a case must depend on the bedside roentgenographic findings (Fig. 47).

In the fractures of the upper third of the shaft below the surgical neck, traction is usually necessary, but seldom need amount to more than two kilos. It can usually be applied by means of glued bands. Suspension is carried out in the usual manner. The amount of abduction necessary will depend entirely on the amount of muscle injury. If the pectoral and latissimus attachments are lost,

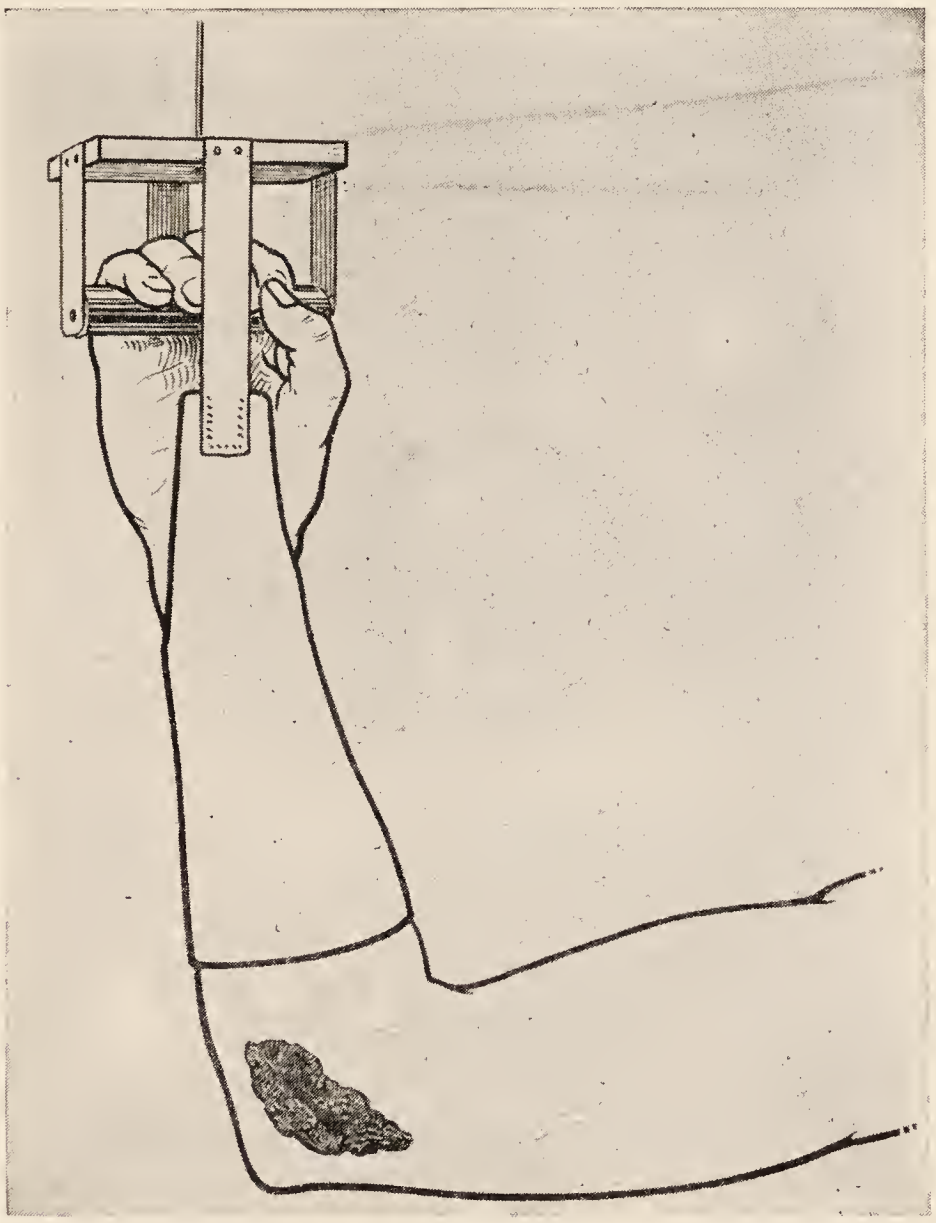


FIG. 46.—Suspension of the forearm in a compound wound of the elbow-joint. The arrangement of the hand spreader (see text) and the lack of support of the upper arm are to be particularly noted.

the abduction requirement will be greater than if these muscles were intact. Generally speaking, these fractures require about 60° abduction. A very simple method of obtaining this consists in a rough unplaned board about 50 cm. longer than the width of the bed and about 25 cm. in width. This is passed between the mattress and bedspring and is held in whatever position desired by friction and the weight of the patient. To its free end is attached an upright carrying a pulley. It can be placed in any position desired. It is essential that this board be rough and unpainted. (Fig. 45).

Humerus, Middle Third.—Fractures of the middle third are suspended in the usual fashion, but require careful attention to prevent antero-posterior

bowing. Traction is usually made at an angle of abduction of about 45° and with a weight of about 1½ half kilos. The concurrent wound is usually such that a Hennequin band must be used and it is in this group of fracture more than any other that the band must be pinned so as to pull exactly in the axis of the humeral shaft. If the band is not pinned sufficiently low, anterior angulation will occur, and if pinned too far posteriorly, backward angulation takes place. The angulation is also controlled by the relative amount of weight used to support the forearm and the arm. Too much weight attached to the



FIG. 47.—Extreme abduction and external rotation in fracture of the surgical neck of the humerus. It will be noted that the frame at the head of the bed has been somewhat modified to meet the requirements (see text, "Humerus, upper third").

forearm results in posterior angulation, while too little allows a sagging of the elbow with resulting anterior angulation.

Humerus Lower Third, Including Resections of the Elbow.—The higher fractures of the lower third are treated exactly as are those of the middle third. Care must be taken that the band supporting the humerus extends well below the site of fracture, as otherwise the elbow will sag and anterior angulation occur. Abduction need rarely exceed 25°. Traction of one kilo is usually sufficient.

After resections of the elbow, traction should never be used. The functional result obtained will depend largely on the operative procedure. If a careful subperiosteal resection, practiced by the Lyon School, is done, early motion of the elbow should be encouraged, with the view to re-formation of the joint. If the periosteum has not been preserved, the best that can be looked for is ankylosis, but a flail joint will more often be the result. Suspension for this second type of case is useful only until the subsidence of the infection in the wound and should be replaced by absolute immobilization of the elbow in plaster as soon as possible. If ankylosis can be obtained, the angle of choice depends on the occupation of the patient. In a laboring man or farmer, about 135° extension gives the most useful arm, while the clerk or draughtsman requires 70°.

In compound fractures of the elbow joint without resection and in suppurative arthritis of the elbow joint, suspension is most valuable, but should be made only by the forearm. The weight of the upper arm then tends to keep the ends of the bones separated and thus facilitate drainage.

Forearm.

The forearm is suspended in a sort of cradle which consists of two round iron bars, each 40 cm. long and 8 or 9 mm. thick, held together by two lighter

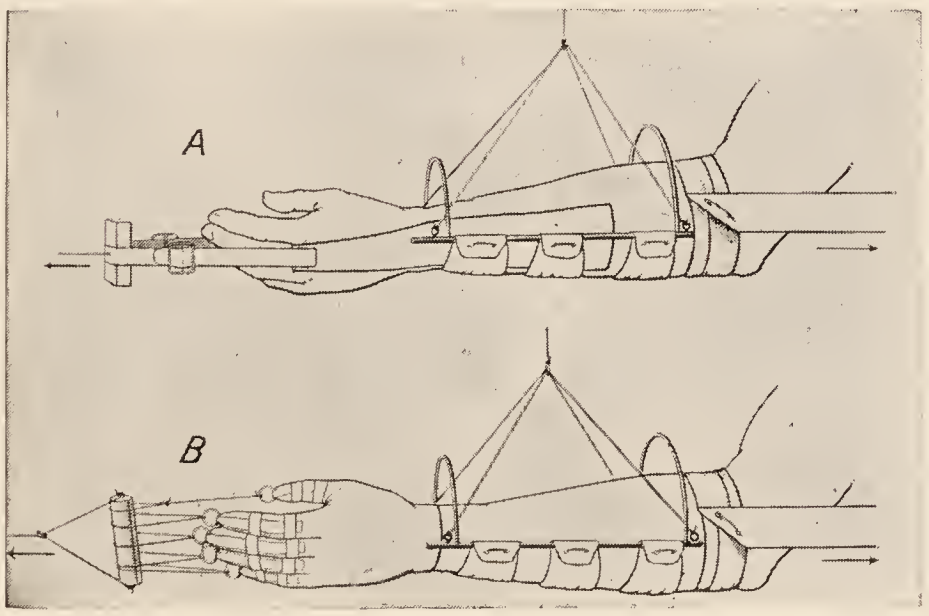


FIG. 48.—The illustration shows the cradle used in fractures of the forearm, the bands supporting the forearm in the cradle, traction either by glued bands *A* or by a glued glove *B*. Countertraction by a Hennequin band is also shown.

curved iron bars riveted by their ends in holes in the parallel bars. The parallel bars are 15 cm. distant from each other, but this distance can be increased by reducing the arc. These arcs pass above the forearm which is suspended by double linen bands sewed to one another. The narrow ends of the bands are passed over the sides of the parallel bars and fastened either with safetypins or metal clips, in such a way that they can be readily adjusted to support the part. When wet dressings or continuous irrigations are used, similar bands of double faced rubberized linen can be employed. If the wounds permit, extension can be made by bands glued to the lower forearm. In lower wounds very satisfactory traction can be obtained by means of a glove. The hand is first thoroughly covered with glue, and then a white cotton glove, to the end of each finger of which has been attached a small metal ring, is drawn on.

Traction is then made through the fingers, as much as 1½ kilos of weight being used. Great care must be taken that at least twice each day the traction is removed and both active and passive motion of all the small joints of the fingers practiced. Full supination is seldom necessary, a point a little short of this usually sufficing to prevent cross union (Figs. 48 and 49C).

In cases with considerable oedema, it is occasionally useful to suspend the forearm, either with band or a glove, in the vertical position. As soon as the condition of the wound permits, the majority of fractures of the forearm, especially if one bone alone is involved, can be treated in molded plaster, as suspension offers no particular advantage.

Femur—General Considerations.

In the treatment of compound fractures of the femur the ideal can frequently not be obtained by any apparatus, but with suspension and traction the results are more satisfactory than by absolute immobilization. The ideal position of

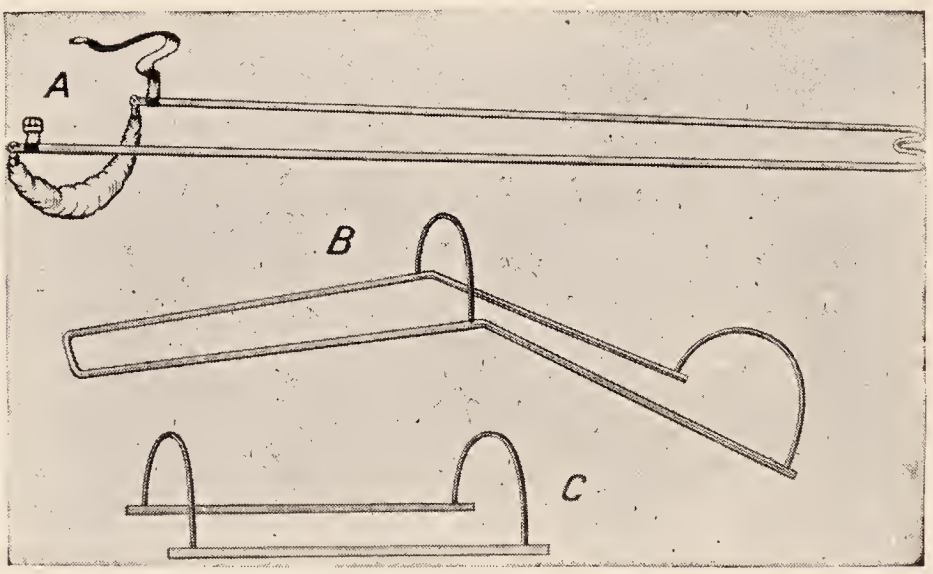


FIG. 49.—Illustrates the three forms of metal splint used for suspension. *A* shows Lieutenant Colonel Keller's modification of the Thomas hip splint. *B* shows Hodgen's splint. This is made in rights and lefts and is not interchangeable. The knee angle can be changed to suit the individual case. *C* shows metal splint for suspension of the forearm. For description see text.

flexion at the knee and hip, thus giving musular relaxation, is often prevented by the fact that the position of the wounds interferes with the application of the traction. However, in the majority of cases satisfactory alignment with little or no over-riding can be obtained, and the freedom of motion of the patient in bed prevents to a large extent the onset of pulmonary complications, probably the most common late cause of death following this type of injury (Fig. 49A and B).

All fractures of the femur, at whatever level, are suspended. Two types of splint are employed. The application of each will be described under the separate fractures. The upper straight splint is a recent modification, by Lieutenant Colonel W. L. Keller, United States Army, of the Thomas splint with ½ an Ischial ring that is movable. The loop for pressure against the pelvis has been hinged at its junction with the parallel bars, thus making the splint interchangeable for each leg. The distal ends of the bars are

connected by a transverse portion which is bent proximally to form a median point for traction. The sliding metal stirrup has been removed (Fig. 49A).

A stout bandage is attached to each traction tape, passed over the side of the parallel bars and over the end of the transverse distal portion of the splint. By means of a pin shorter than the width of the splint the two parts of the bandage are brought together and twisted, as is a tourniquet, thus shortening the distance between the sole and the end of the splint and obtaining traction. When sufficient lengthening has been obtained, the pin used for twisting is slipped slightly

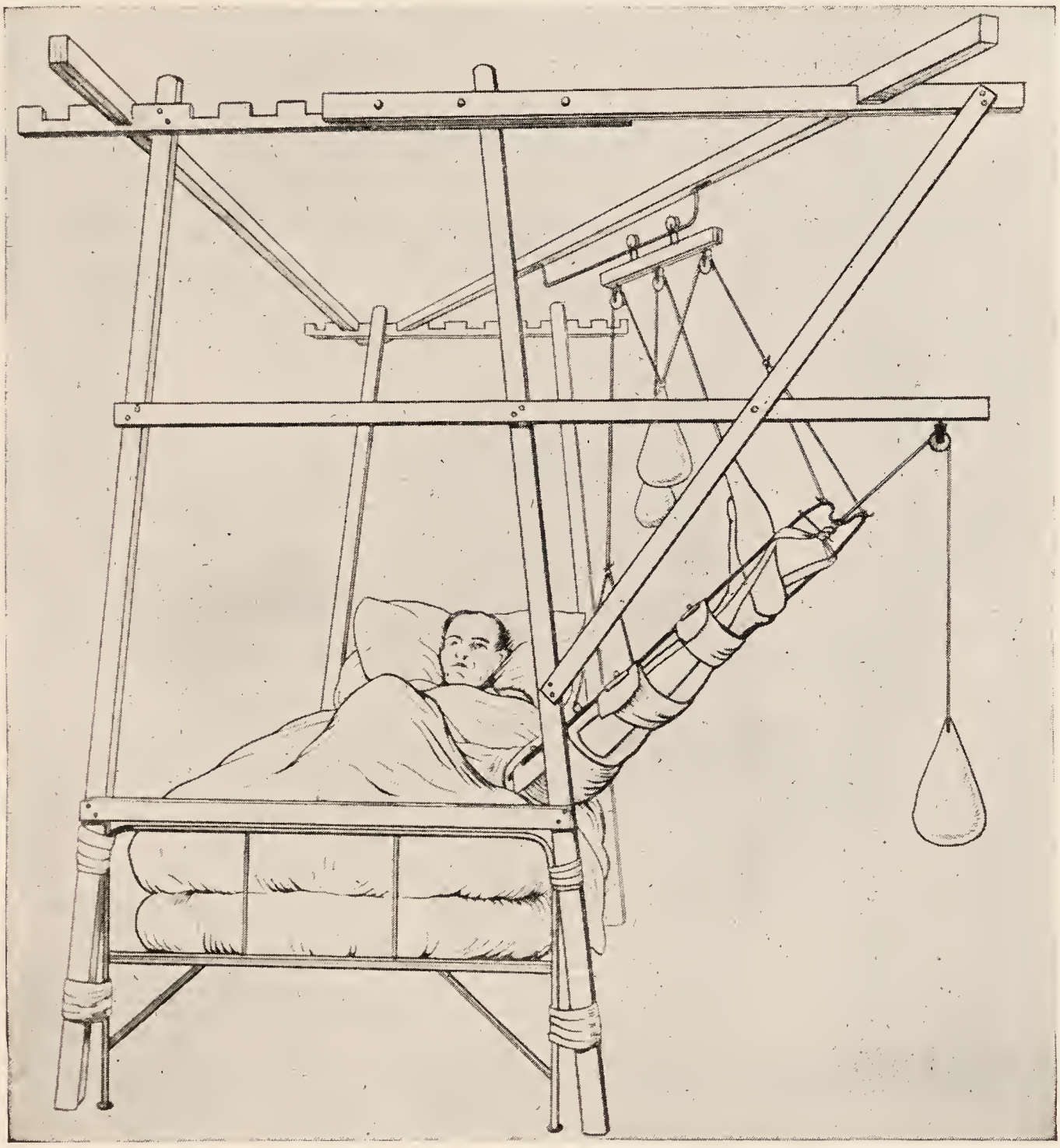


FIG. 50.—To show the use of the straight splint and the method of obtaining the traction. Note especially the building out of the foot of the frame, the side abduction obtained, the angle of the supporting longitudinal bar closely corresponding to the angle of abduction of the leg, and the tourniquet method of obtaining traction within the splint. The method of preventing foot drop is also shown.

eccentrically and allowed to bear on one end of the splint, in this way maintaining the traction. Counter traction has in the meantime been obtained by the pressure of the upper end of the splint on the pelvis, but as this is uncomfortable for the patient and apt to lead to bed sores if continued, it is relieved by traction on the entire splint by weights over the foot of the bed. This latter traction is, of course, omitted for purposes of transportation. The limb is suspended in

this splint by means of the bands. The splint itself is suspended by means of a trolley. Hodgen's splint is usually employed (Figs. 50 and 52).

The angle at the knee can be changed to suit the requirements of the case, as will be explained later. The cord supporting the upper portion of this splint passes to a pulley on the opposite longitudinal bar to that by which the limb is suspended in order to prevent the patient from sliding in bed and to prevent lateral inclination of the splint. The apparatus is usually better balanced if the distal suspension cords are attached one at about the level of the malleolus and the other at about the level of the knee. The weights used for suspension of either splint should exactly counter balance the weight of the limb and must accordingly be varied for each case. As has already been mentioned in describ-

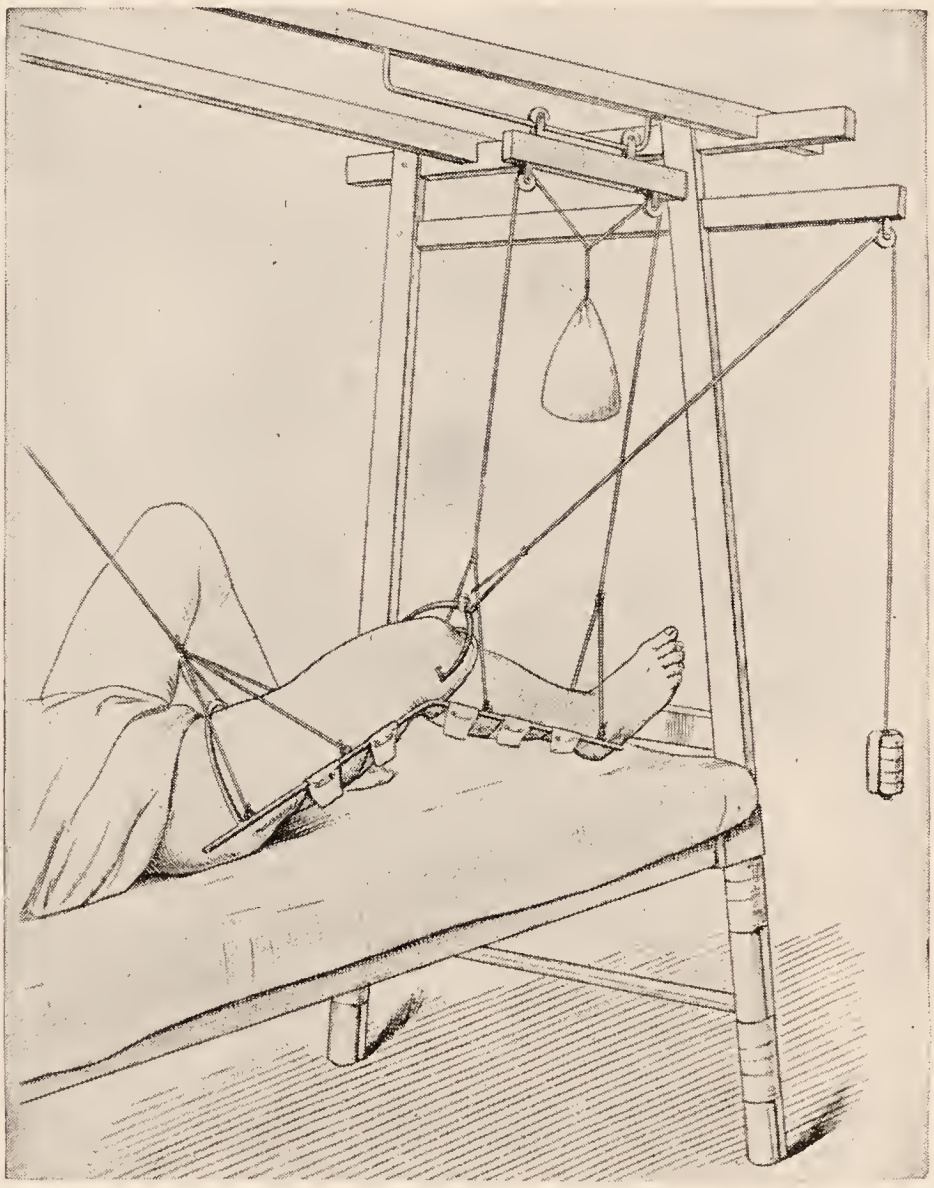


FIG. 51.—Showing the arrangement for a fracture of the upper third of the femur. A steinman nail has in this case been used. Note the flexion at the knee, the abduction and external rotation. The arrangement for the control of foot drop has not been figured (see text).

ing fractures of the upper extremity, each fracture should be roentgenographed in bed *after* clinical reduction is perfect. And the principle of invariably following the axis of the upper fragment with that of the lower must always be kept in mind.

Traction for fracture of the femur can be obtained in one of three ways: (1) by glued bands; (2) by direct bony skeletal traction as by a Steinman pin or a Finochetto band; or (3) by pressure on the calf with a well-flexed Hodgen's splint (Figs. 51 and 52).

Glued bands for fracture of the femur are usually unsatisfactory, but must be occasionally used, especially with a straight splint. Much of the traction is

lost, being transmitted to the pelvis by the skin and deep fascia. Consequently 10 to 15 kilos of weight are needed.

With skeletal traction, especially with a Steinman pin through the femur, about one-third of this weight is necessary. It is the ideal form of traction provided the question of infection can be eliminated. It is especially applicable in fractures of the upper half of the femur in connection with a well-bent Hodgen's splint.

In the third method of applying traction, the knee is flexed and the tractive force is applied against the back of the calf. This is ordinarily accomplished in one of two ways. In Hennequin's method, the limb, as high as the mid thigh,



FIG. 52.—Illustrates the method of suspension in fractures of the lower leg. The splint is bent to about 135 degrees. The middle suspension cord is attached too far up the splint, which would balance better if this cord were attached nearer the knee (see text).

is surrounded by a very thick dressing of non-absorbent cotton snugly bandaged in place, the knee must be kept in flexion while the dressing is applied and it is well to put a wet crinolin or very thin plaster of paris bandage over all to keep the dressing in place. A figure-of-8 *hitch* is then made about the thigh and knee by means of a sheet folded several times so as to make a band 1½ meters long and 15 cm. wide. This is probably the best method when the Steinman pin cannot be used for high fractures of the femur. It obviously cannot be used in cases with low wounds of the thigh. The other method of calf traction is to bandage the leg to a well-bent Hodgen's splint and make the traction on the latter. This method affords access for dressing to wounds in

the lower part of the thigh, but is scarcely applicable for initial traction because the pain and pressure on the calf are too great. Later, when less traction is needed, it becomes a very serviceable method.

The arrangement which we use for preventing foot drop in all the cases of fractured femur and in some cases of fracture of the lower leg, depending on the form of traction used, deserves a word of explanation. A canton-flannel traction band as used for the arm, is glued to the sole of the foot and extends a short distance beyond the toes. This band is attached to a cord which runs in a pulley attached to the trolley above the bed and has attached to it about ½ kilo of weight. This maintains the length of the tendo achilles and at the same time gives a movable support against which the patient can exercise the ankle. Rotation of the lower fragment can to a certain extent be controlled by changing the angle at which this band is glued to the sole of the foot.

Femur, Upper Third.—In fractures of this portion of the femur the abductor and external rotator group of muscles are seldom destroyed and almost never lose their nerve supply. They accordingly continue to functionate, with resulting wide abduction and external rotation and some flexion of the upper fragment. For fractures at this level the Hodgen's splint is generally used. Wide abduction, together with considerable elevation and external rotation, is the position of choice, this elevation helping to maintain countertraction by the weight of the patient's body. If there is a tendency for the patient to be pulled downward, additional countertraction can be obtained by moderate elevation of the foot of the bed. The amount of traction needed depends to a certain extent on the loss of bony and soft tissue, on the musculature of the patient, and on the length of time after injury when it is started. As a general rule, it is advisable to make strong traction during the first week, as greater lengthening with less weight can be obtained then than later. Ten kilos is usually sufficient, but the amount of weight used must be carefully controlled by accurate measurement and roentgenography.

External rotation of the lower fragment is obtained by elevating slightly by means of the suspension cords the inner side of the splint and by applying the band glued to the sole of the foot diagonally from the outer side of the heel well to the inner side of the great toe.

If the situation of the wounds is such that the use of a pin appears dangerous because of possible infection, excellent traction can be obtained by the method of Hennequin, using a wide and well-flexed Hodgen's splint (see "Femur, General Considerations"). If, for any reason either a Steinman nail or the Hennequin method cannot be used, the limb is put on a straightened Hodgen's splint, traction being made by bands glued well above the knee, with wide abduction, external rotation and flexion at the hip. Or a Finchetto stirrup can be employed. At least 12 kilos traction will be needed in order to stretch the hamstring and overcome the weight of the limb.

Femur, Middle Third.—In these, the wounds are in the middle of the thigh and do not interfere materially with the use of any splint. But the method of Hennequin cannot be well employed. The position assumed by the upper fragment is in abduction if the fracture is above the adductor longus insertion; otherwise it is nearly straight. It is moderately flexed and rotated out.

The method of treatment depends on whether a Steinman pin can be used or not. If it can be used, the limb is put in a well-flexed Hodgen's splint with the knee and hip flexed, and is suspended in a position of moderate abduction and rotation outward. A traction weight of four to five kilos is to be used at the outset.

If the Steinman pin cannot be used on account of infection, extension straps or the stirrup are used with a straight Hodgen's or modified Thomas splint (the latter gives better lateral control of the fragments) and the limb suspended in a position of a slight abduction and flexion at the hip with rotation outward. A traction weight of 10 to 12 kilos is used at the outset.

Femur, Lower Third.—These fractures are very difficult to treat on account of the position of the wound which often prevents the application of the proper method.

The position assumed by the upper fragment is practically in line with the body, the tendency to flexion being overcome by the sheath of the surrounding muscles. It rotates outward about 30°. The lower fragment, however, flexes at the knee, and in order to get it in line with the upper fragment, the knee must be flexed. The only efficient way in which to apply traction with this position of the knee is by means of the Steinman pin and this should be used in all clean cases. Treatment then is simple and the leg is put up as described for fractures of the middle of the shaft, with a weight of three to four kilos.

But in the majority of cases the Steinman pin cannot be used on account of infection, and then one is forced to use treatment bad in principle, namely, to put the limb up in a straight splint with extension straps or the stirrup for traction and wait until union is just beginning, but the fracture line is still soft and pliable. The straight splint is then removed and a Hodgen's splint, angulated to about 110°, put on. When the limb is bent on this splint, flexion will not take place at the knee, which will have become stiffened, but at the fracture, and the fragments will be brought into line. To be successful, strong traction must be made up to the time of changing the splints, so that the muscles are actually over-stretched and all over-lapping overcome.

Fractures of the Tibia and Fibula.—All wounds and fractures of the leg repair far more quickly if the limb is suspended, and this should always be done. The Hodgen's splint bent to an angle of 135° is employed. The leg is suspended in the splint by the usual bands and the splint suspended above the bed by the trolley previously described. Countertraction is obtained by the portion of the splint supporting the thigh, care being taken that the upper suspension cord passes to the longitudinal bar on the opposite side of the bed.

Fractures of the fibula alone are of little consequence, being well supported by the tibia. They are suspended because of the improvement in circulation and for the dressing of wounds, but no traction is necessary.

Fractures of the tibia alone are splinted by the fibula and are prevented from over-riding to any great extent, but incurvation is common. A slight traction of one to two kilos will correct this tendency.

Fractures of both bones demand more care. Here traction of three to four kilos is necessary.

Four methods of traction have proved most satisfactory. They are more or less interchangeable, but each has its advantages.

A traction by a gaiter is made of two layers of unbleached muslin lacing across the instep and provided at each side with a tape to fit the buckle of the spreader. The ankle should be well padded beneath the gaiter with cotton. It is necessary to use a glued band to the sole of the foot to prevent foot drop (Fig. 53A).

Traction is effected by bands glued to the side of the leg. Foot drop suspension is also necessary. A fair purchase can be obtained, if necessary, by very much shorter bands (Fig. 53B).

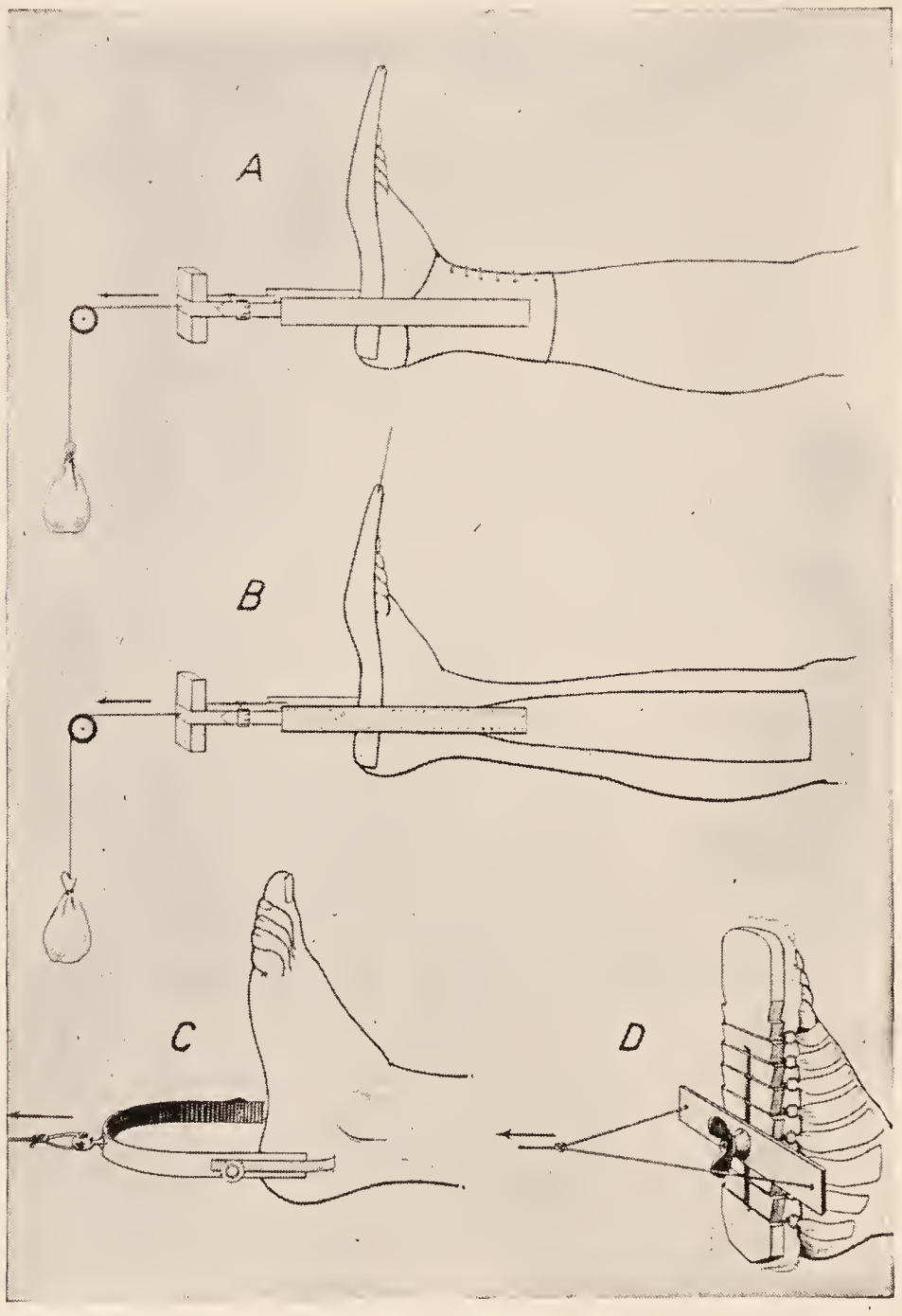


FIG. 53.—To illustrate four methods of obtaining traction in fractures of the leg (for detailed description see text).

A Finchetto's band is very efficient and can be inserted with local anaesthesia. It should be used only where a clean local operative field can be obtained, for in the presence of infection the band cuts deeply into the os calcis. No suspension of the foot drop is necessary (Fig. 53C).

Sinclair-Smith's "skate" is an exceedingly useful and ingenious device. It consists of a block of wood a little longer than the foot and very slightly wider, in the free edge of which are cut about 10 notches. Its centre contains a longitudinal slit through which passes a bolt provided with a thumb nut on the exposed side. The side of the board toward the foot is padded with cotton and covered with gauze. The transverse bar is a piece of iron 5 mm. thick,

2 cm. wide, and 15 cm. long, with a hole at the centre and at each end. With glue 8 or 10 narrow tapes are pasted along each side of the foot, each tape having previously had attached at the end toward the sole a small curtain ring. The bands over the dorsum of the foot do not meet in the midline, but leave a free area to prevent constriction and interference with circulation. The foot is fastened to the board by lacing the rings on each side to each other on the under suface of the board. The apparatus forms practically a ball-and-socket joint for the control of the position of the foot. The lower free edge of the transverse metal bar rests on the parallel bars of the Hodgen's splint and maintains the position of the foot in the position in which it is placed (Fig. 53D). To elevate or depress the foot as a whole (correct anterior or posterior angulation at site of fracture), the wooden block is slipped upward or downward on the transverse bar, and the thumb screw tightened. To abduct or adduct the foot (rotate the lower fragment inward or outward), the block is rotated on the transverse bar and there fixed. To pronate or supinate the foot as a whole (correct lateral angulation at site of fracture), the cord leading from one extremity or the other of the transverse bar is shortened. The "skate" is especially useful in very low fractures of both bones and in fractures involving the ankle joint.

Fractures of the Tarsus and Metatarsus.

These are commonly also treated by suspension, largely for the improvement in circulation obtained and the consequent more rapid healing. In those fractures involving the ankle joint, traction by means of a Sinclair-Smith "skate" is used.

Traction otherwise is not indicated, but suspension to prevent foot drop should be used.

An irrigating bottle rack can be provided on one of the uprights nearest the compound fracture for Dakin or salt solution.

CHAPTER IX

MISCELLANEOUS POINTS IN ORTHOPAEDIC TECHNIQUE

Preparation of the Skin for Operation.

It will be found not only a saving of time when the operator is ready to proceed, but a safe-guard against infection of the patient to sterilize the skin 24 hours in advance of the operation and the older method of doing this is safer in the opinion of the writer than the Iodine and Alcohol method now in vogue.

This old method consists of: (1) Shaving the limb from toes to groin or fingers to axilla. The shaving must be done carefully and thoroughly. This whole region must be sterilized for almost invariably the entire limb has to be manipulated or handled during the operation and must be sterile to avoid infecting the operator's or assistants' gloves.

2. Thorough scrubbing with green soap, gauze handkerchiefs and ample warm water.

3. Applying solutions of Permanganate of Potassium (½ an ounce to eight ounces) and Oxalic Acid (½ an ounce to eight ounces) by means of gauze handkerchiefs, the former pigmenting the skin and the latter decolorizing, as antiseptics.

4. Thorough washing with alcohol and then ether applied with gauze, to free and cleanse the skin of oily and fatty impurities.

5. Wrapping and covering the entire limb in towels wet with 1–5000 Bichloride of Mercury solution and keeping these wet by covering with non-absorbent glazed cotton until the patient is anaesthetized. These towels are kept in place by suitable bandages *by turns around the pelvis or thorax*, as the case may be, which keep the entire limb covered. These are often carelessly omitted and the dressing slides off and the preparation must be done over.

At the time of the operation, the non-sterile nurse or assistant simply cuts these bandages and turns back the bichloride towels, so that the gloved hand of the operator may grasp the sterile limb, while the remainder of the towels may be removed and the sterile sheets put on the operating table and the operation begun without further to do, unless the operator desires to wash over the immediate field of incision with a handkerchief saturated with alcohol.

The Bloodless Field of Operation.

In many instances it is expedient to operate in a bloodless field to be enabled to differentiate tissues and anatomical structures and the nurse should have ready a sterile Esmarch rubber bandage, two, three or four inches wide, depending on the age and size of the patient, and a sterile bloodless bandage or constrictor at hand, preferably the United States Army Constrictor or an elastic piece of black rubber tubing, ½ an inch or more in diameter.

After sterilization, the clean operating-room nurse should dry the Esmarch bandage thoroughly with sterile towels and roll it snugly with the terminal tapes in, because when wet and loosely rolled it is next to impossible to apply them properly.

In using the Esmarch bandage considerable tension should be made on it to apply it tightly for the first few turns around the hand or foot and this tension is later distributed up the limb and squeezes the excess blood out of the veins (Fig. 54).

In applying the constrictor above the condyles of the elbow or near the axilla one or two gauze handkerchiefs should be placed on the inner side to protect the nerves from undue pressure, for fear of operative paralysis and for

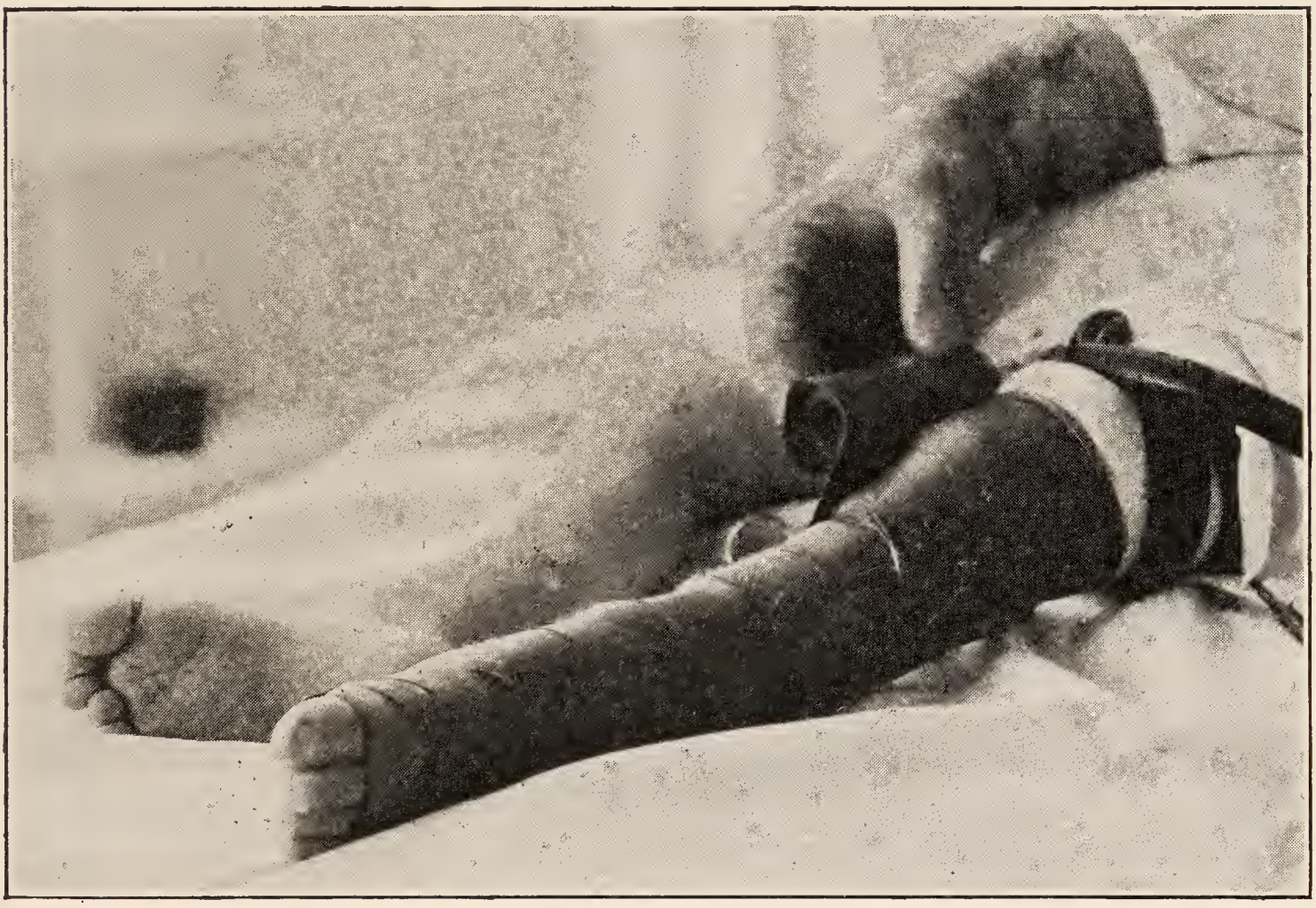


FIG. 54.—Esmarch applied.

the same reason *three or four turns* of the constrictor should be taken around the limb close together *to broaden the pressure* before tying the slip knot.

Avoidance of moving the limb after the circulation is cut off and especially assistants or nurses are cautioned against leaning on the slip knot, as observing these precautions will do much to prevent loosening the constriction and maintain the bloodless field (Fig. 55).

Sometimes it is desirable to fasten the knot with a Kelly Haemostat, but this is apt to injure the rubber in a good constrictor and should be resorted to only if it is found to slip and loosen, even where the other precautions are taken.

Closed Method of Ether Anaesthesia in Children.

In anaesthetizing children, we naturally wish to minimize the dosage of the drug, so that unconsciousness and relaxation will rapidly occur and the patient will with equal rapidity regain consciousness.

This, in the experience of the writer, is facilitated and safer by the "closed method" than by the "drop method" and the dosage is measured more accurately by the former.

By the "drop method" we do not know how much is evaporated into the room and how much the patient gets; it is also more wasteful of ether.

Cones are made in three sizes, for babies, children and adolescents respectively, from sheets of old desk blotters, for a foundation, covered with oil silk and finally with muslin and pinned into the cone shape.

Convenient sizes to cut the blotter will be found to be 6 by 8, 8 by 10 and 10 by 12 inches.



FIG. 55.—A bloodless field.

Rubber tissue and absorbent cotton moistened with water or boric solution is placed over the eyes for protection from ether irritation.

Into the apex of the cone is placed a good bit of absorbent cotton, upon which ½ drachm of oil of orange blossom may be poured and allow the child to breathe in the "cologne."

A few drachms of ether is then poured into the cone and as rapidly as possible it is brought down on the child's face and *kept there.* The more air is excluded, the more rapidly will the child "go under." This is facilitated by placing a partially folded towel under the child's chin and over-lapping the cone.

When additional ether is to be put into the cone, it should be done as quickly as possible and the cone replaced at once, with the same exclusion of air.

Ample space should be maintained in the cone between the etherized cotton and the child's nose and mouth.

Ether given in this manner will often permit a child to wake up almost as soon as the operation is completed and be less drugged. This recovery from

the effects of the anaesthetic is also facilitated by wrapping them up in blankets and allowing them to "come out" *on a sleeping porch* or *near an open window* and with less nausea. As a rule one will find windows and doors tightly closed for fear of the patient "catching cold" or "getting pneumonia" or "acute uraemia." The sooner the ether is eliminated the better and therefore we should avail of a maximum of fresh air.

CHAPTER X

TENOPLASTY, OSTEOCLASIS, OSTEOTOMY AND BONE GRAFTING

Tenoplasty.

The operative procedures on tendons which comprise what are termed Tenoplasties are those which are employed as follows: to correct undue shortening or undue lengthening; to transfer the tendon of a living muscle of minor importance to the insertion of a tendon of a paralyzed or destroyed muscle of major importance, to partially restore function, and is called "Tendon Transplantation;" to utilize a tendon of a paralyzed muscle by suture above and below a joint to effect joint stability, to prevent "foot drop" and similar aims.

As the tendons are often minute, slippery, hard to handle and enclosed in sheaths, which communicate with synovial or serous spaces and bursae and require the most scrupulous asepsis and a bloodless field to detect carefully the minute structures and relations of parts, one must not lose sight of the importance of avoiding scarifying or traumatizing the tendon, which one desires to glide or slide smoothly through its sheath or the new plastic sheath which is formed: in other words, it must be borne in mind that we wish to avoid post-operative adhesions. This is best accomplished by avoiding undue instrumental handling of tendons and *never with sharp-toothed instruments* that crush or tear or puncture the surface of the tendon, by avoiding undue exposure of silk sutures and knots in the course of the tendon and also by preventing drying out of the exposed tendon by keeping it constantly moistened with absorbent cotton, *not gauze*, wet in normal salt solution. Sponging should similarly be done with moist absorbent cotton. (See Reconstruction of the Hand.)

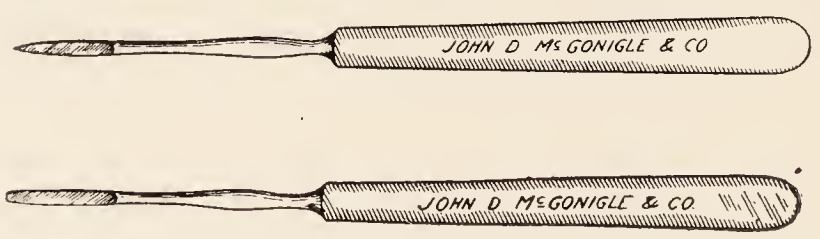


FIG. 56.—Tenotomes, sharp and blunt.

The preparation of an aseptic and bloodless field for these operations has been detailed in the preceding chapter.

The instruments required for a tenoplasty consist of two scalpels, one for skin and one for deeper structures, a few mosquito clamps and Kelly haemostats, two or three grooved directors, large and small, two small retractors, two Allis or Kocher clamps, fine intestinal silk and cambric needles, full curved Hagedorn needles, the author's special non-traumatizing tendon holders and a sharp and a blunt tenotome. The last named are small knives, one pointed, sharp on one edge and with blades about ¾ of an inch long and ⅛ of an inch wide at its widest part and the other blunt, straight, ¾ of an inch long, with one cutting edge and ⅛ of an inch wide throughout its length (Fig. 56).

Lengthening Tendons.

The most frequent operation for lengthening a tendon, is subcutaneous tenotomy of the tendo achillis for shortened heel cord, producing "foot drop" or Talipes Equinus. For this, as a rule, only the sharp and blunt tenotomes are required and no bloodless field is necessary, as a simple puncture is made with the sharp tenotome flat against the medial edge of the tendon; it is then withdrawn and the blunt tenotome is introduced into the puncture and rotated 90°, so that its cutting edge lies under and across the tendon. Then by a slight sawing motion, the tendon is cut entirely through and across; malposition of the foot can now be corrected or over-corrected, as the case may require, dressed with aseptic silver foil and gauze and put up in a plaster of paris cast. A plastic material, like "callus," forms between the severed ends and in four or five weeks organizes into tendon, so that the tendon is lengthened by the interval we have secured at the time of the severance and correction.

In some instances at the heel cord and in other tendons to effect lengthening it may be necessary after open incision to cut through the tendon obliquely, slide the component parts on each other sufficiently to obtain the desired correction and suture from end to end the approximated portion by buried sutures.

A method of lengthening a tendon without suturing, is to cut two-thirds across from the near side and then down vertically one-half the proposed lengthening; about ⅛ of an inch below on the far side, a transverse incision is made two-thirds across and vertically upwards to within ⅛ of an inch of the first incision. When the tendon is then stretched, it first assumes the shape of the letter "N" and then straightens out the desired length (Fig. 57).

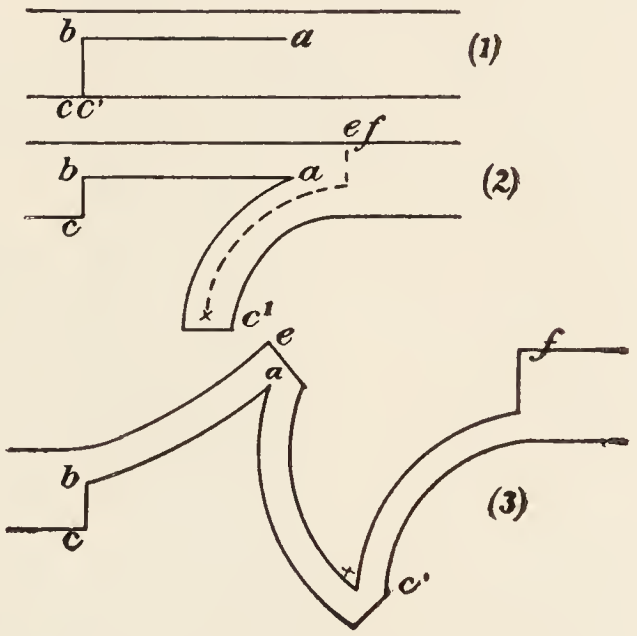


FIG. 57.—Lengthening a tendon without suture. (*Stewart.*)

Another method of lengthening is by cutting the tendon half through above on one side and at a distance below one-half of the desired lengthening, half way through on the other side. Then these two incisions are joined by incising the tendon vertically from one to the other. This last incision severs the tendon and the contracture can be overcome and the ends sutured as an end to end anastomosis by buried sutures. (See Reconstruction of the Hand for Suture Method.)

Shortening Tendons.

After exposure of the tendon, it is grasped by two of the author's fenestrated Tendon Clamps, leaving an interval between them, which is the amount it is desired to shorten it. This interval is then cut out with a sharp scalpel. A suture of fine silk is then put in with a fine cambric straight needle on each end in the following manner: the tendon is transfixed by one of the needles, which immediately is directed through the fenestra in a zig-zag course of 45° until it emerges at the end of the tendon. Similarly the other needle takes the reverse course and emerges on the end of the tendon, care being taken in each instance

to have little silk exposed, a mere dot, as the needle emerges and enters the tendon on the sides. The other tendon segment is sutured in an identical manner. The sutures in the segments are tied and buried as the tendon segments are approximated end to end. This method of suture and end to end anastomosis should be used in the last described method of tendon lengthening also (Figs. 556–559).

Tendon Transplantation.

In order that a tendon may pull in a new direction when transplanted, it should be freed with a sufficient amount of length to reach to its new attachment and so that its direction from its origin to its new insertion should be in as straight a line as possible and not around a corner, as it were, to avoid friction. (See Infantile Paralysis.)

In the writer's experience, muscular tone is not quite sufficient to "take up slack" after tendon transference and therefore when sutured in order to obtain the position ultimately desired the deformity should be "over-corrected," thus

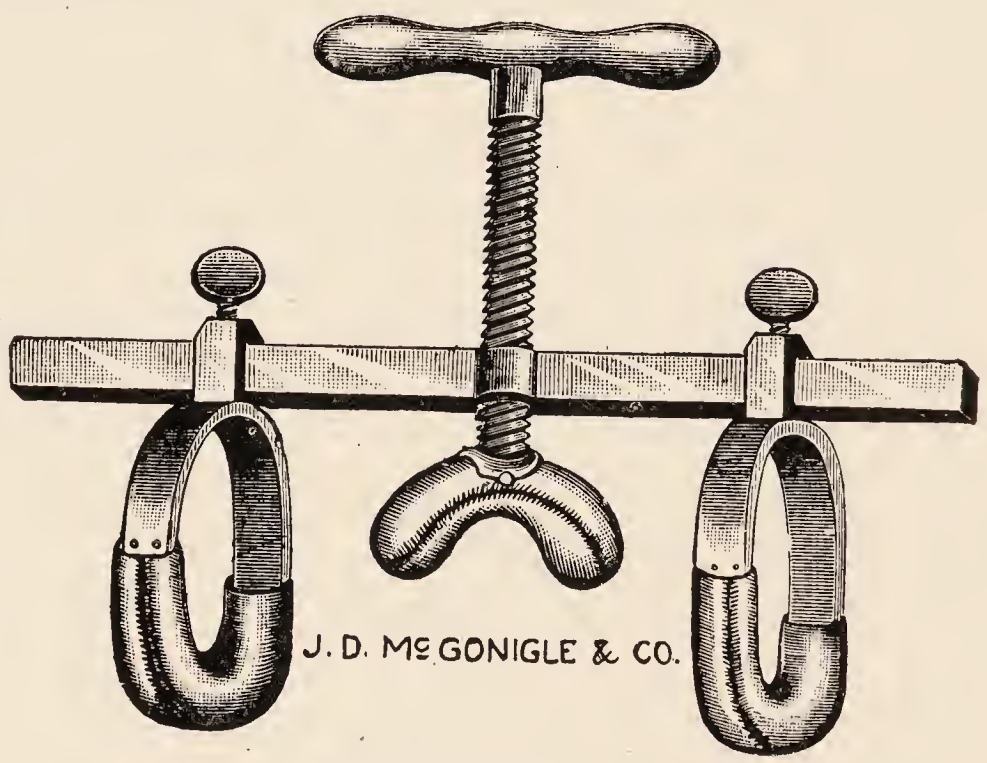


FIG. 58.—Rizzoli Screw Osteoclast.

the tendon must be *under tension* when sutured in place. When a tendon is sutured to a bone, a slit should be cut in the periosteum and bone and the tendon's end securely sutured to it to secure a firm attachment and healing there and prevent future pulling loose, which would of course vitiate the aim of the operation.

It is a mistake to split a tendon longitudinally, free and transplant one-half and expect half to pull one way and half another or, in other words, to "serve two masters," and it is also a mistake to suture one tendon to several tendons for the same reason. Adhesions will probably form which will defeat the object we have in view. Tendon transplantation has as a maximum aim the restoration of some lost function and its minimum aim is to correct some malposition or deformity.

Osteoclasis.

Osteoclasis is an operation for the breaking of a long bone and the correction of a deformity or curvature. It is effected by an instrument known as an *Osteoclast* (Figs. 58 to 64).

Most Osteoclasts depend on two points of resistance on the machine to be adjusted near the ends of the bone and a movable point of pressure to produce

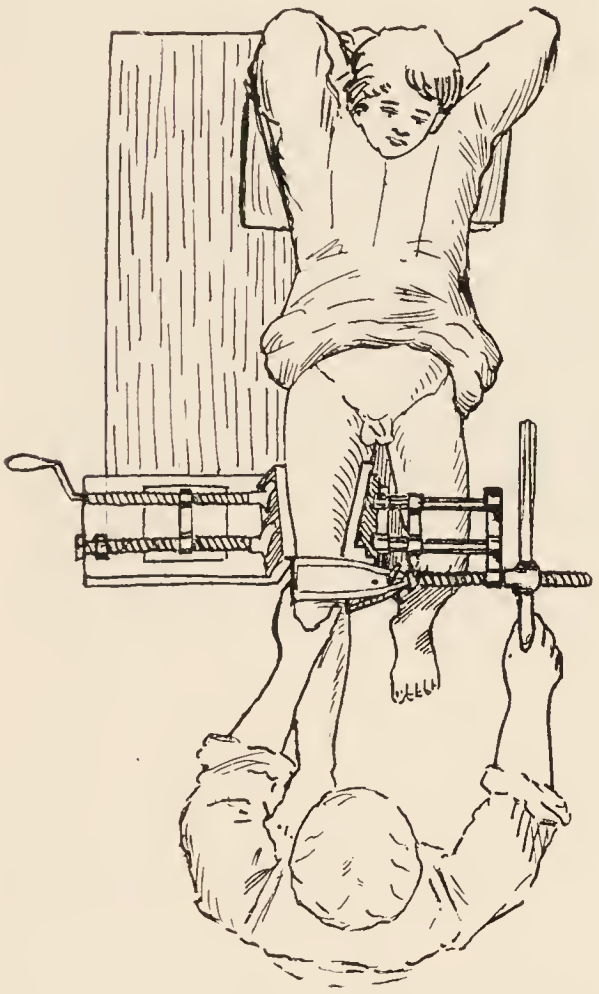


FIG. 59.—Lorenz screw osteoclast. (*Hoffa.*)

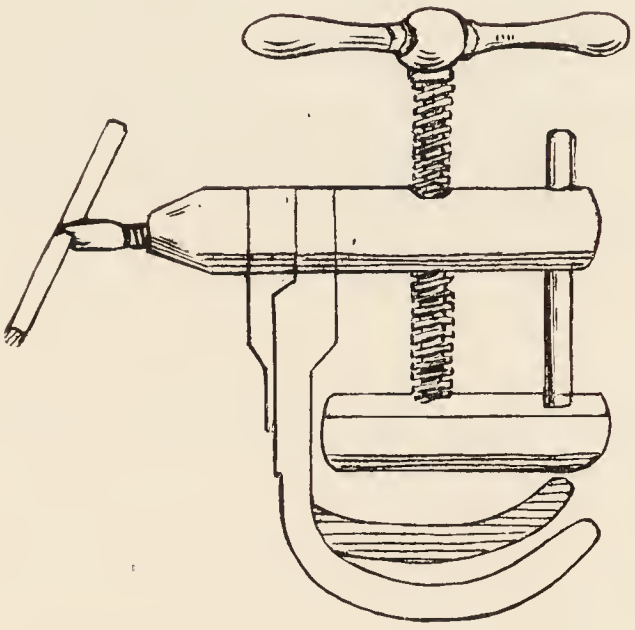


FIG. 60.—Grattan's screw osteoclast.



FIG. 61.—Grattan's screw osteoclast applied. (*Blanchard.*)

a linear fracture at the apex of the curvature or angle. The points of resistance are usually stationary but adjustable and the point of pressure in most machines

is actuated by gradual screw force. In the writer's Osteoclast, the forward thrusting adjustable steel rod and leather covered pressure pad are controlled by a rectangular long- and short-armed lever by which immediate pressure and release are possible and the two points of resistance are adjustable C-pieces of

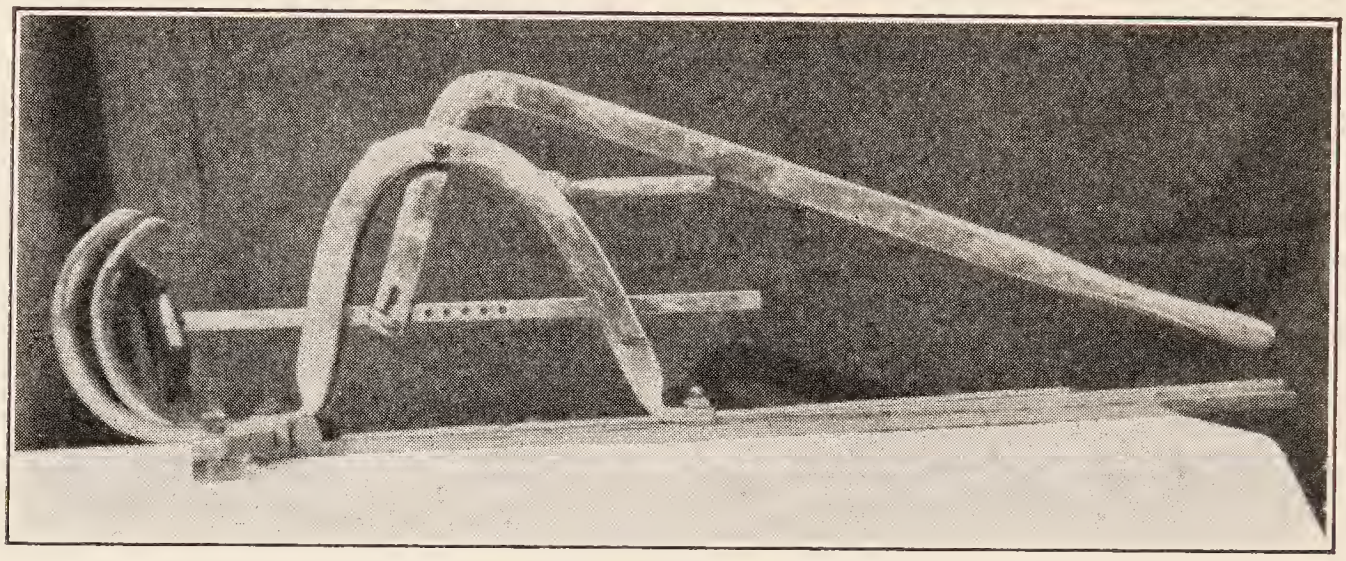


FIG. 62.—Author's lever osteoclast.

steel, all supported on a T-shaped base. Osteoclasis is used chiefly for the correction of bow-legs and requires no preparation of the skin, for the bones are broken subcutaneously.

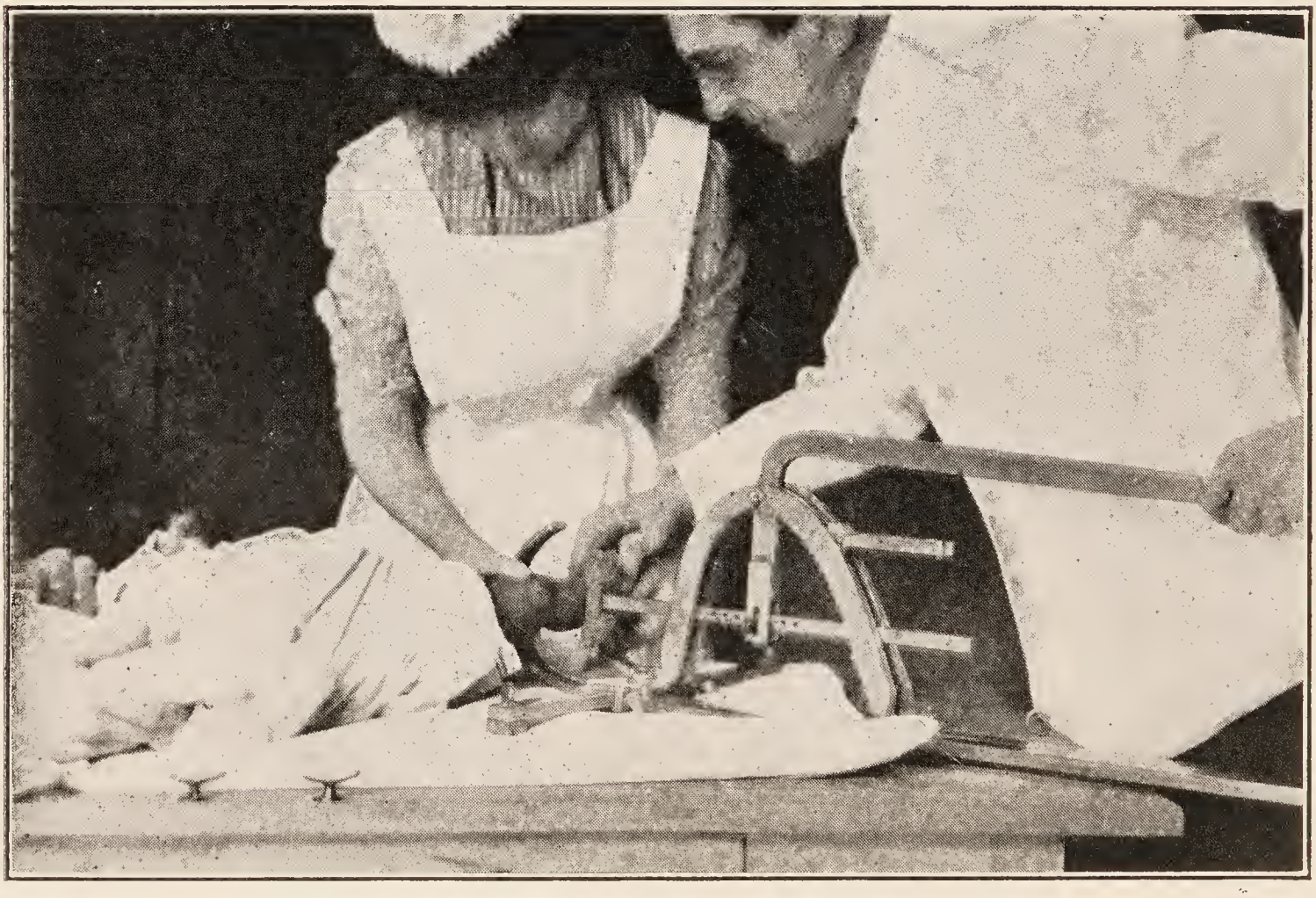


FIG. 63.—Author's lever osteoclast applied.

Osteotomy.

Osteotomy, on the other hand, is an aseptic operation of cutting the bone with a chisel for the correction of deformity or bone curvature. The special instruments for this form of bone operation are known as *Osteotomes* and are like

long, slender steel wedges, which gradually approach a point and have a temper between that of a cold chisel and a carpenter's cutting chisel, so that the edge will not be turned by the hardness of the bone, but at the same time cut into it, and not so sharp as the carpenter's tool or ordinary bone chisel for fear in doing subcutaneous osteotomies that the instrument might slip and there be danger of cutting large vessels or nerves. A chisel differs from an osteotome in

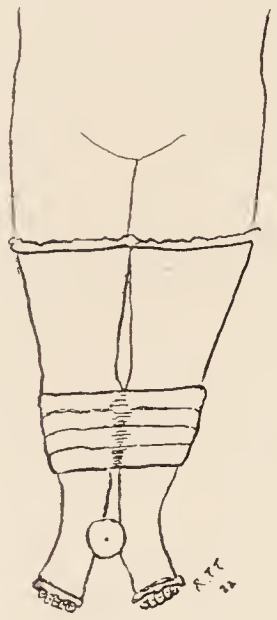


FIG. 64.—Patient with plaster cast applied after osteoclasis.

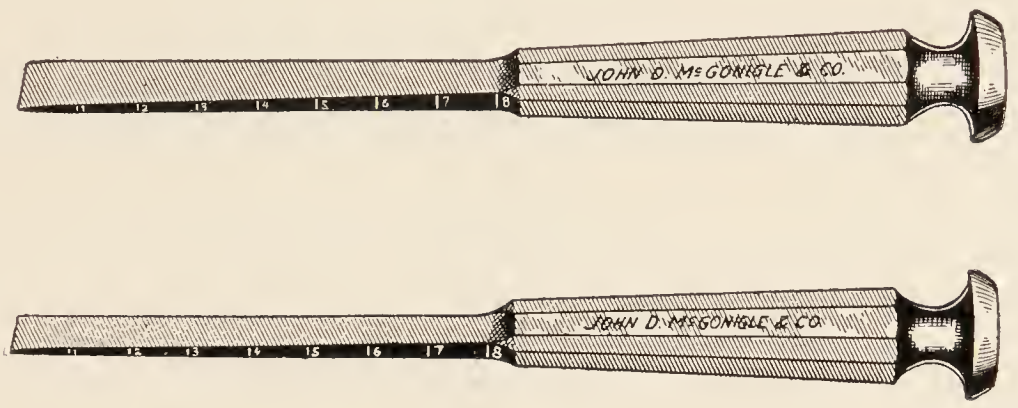


FIG. 65.—MacEwen osteotomes.

that one side is bevelled off suddenly near the cutting end, while both sides of the osteotome approach the cutting edge equally as a wedge. (Fig. 68).

The author has found MacEwen Osteotomes the most satisfactory (Fig. 65). They are graduated on one side in centimeters, so that an operator may know at a glance how deeply he has driven the instrument into a bone. The most convenient widths are 1 and 1½ cm. (Figs. 65 to 68).

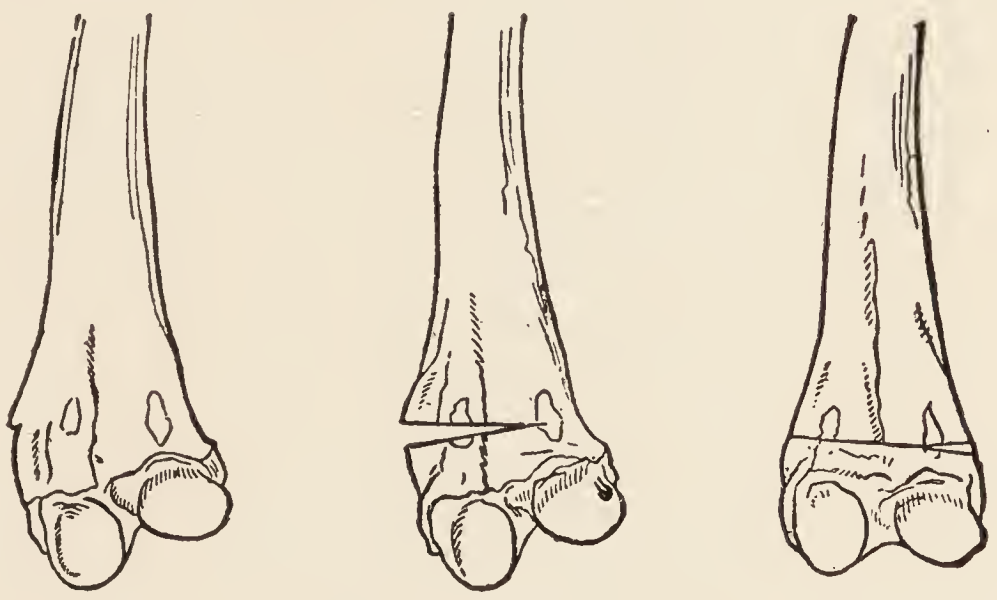


FIG. 66.—MacEwen subcutaneous osteotomy for knock knee. (*Binnie.*)

When driven deeply into bone, in order to loosen it, the osteotome should be worked from side to side and *not from before backwards* for fear of snapping it off in the bone, which would probably occur across its narrowest diameter, and further, a fan-shaped cut may be made in this way, which is also an advantage.

A *subcutaneous osteotomy* is one in which the osteotome is driven directly through the skin and sufficiently through the bone to permit of fracture at the

desired point leaving a hinge of undivided bone and periosteum to keep the fragments in position. A *linear osteotomy* is cutting a bone in a straight line. A *cuneiform osteotomy* is cutting out a wedge of bone and is used when a linear osteotomy and impaction or separation will not correct.

The ordinary steel or steel and lead bone-hammers sold in the instrument shops are unsatisfactory and noisy. The ice-cracking wooden mallet or pref-

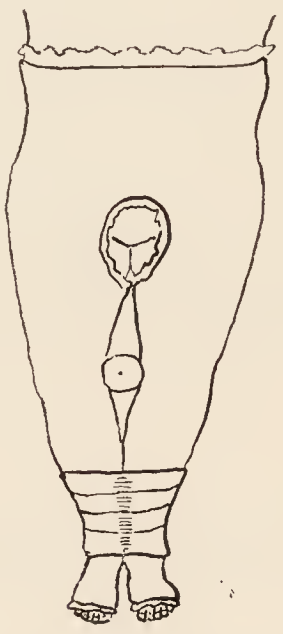


FIG. 67.—MacEwen subcutaneous osteotomy cast applied.

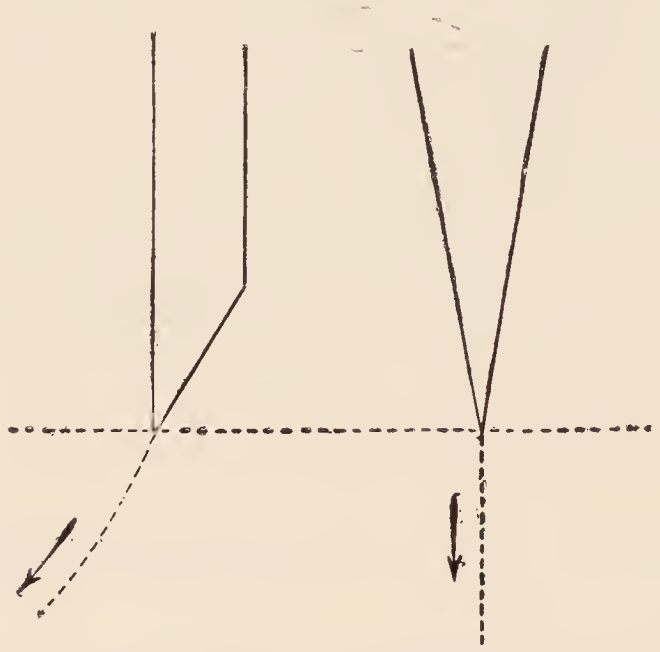


FIG. 68.—Chisel and Osteotome. (*Binnie.*)

erably a curved lignum vitae head on a steel handle, as made for the author, is to be preferred (Fig. 69) as the latter follows the arc of the stroke and the flat of the hammer's face strikes the osteotome or chisel and not a small glancing portion of it as with square hammers.

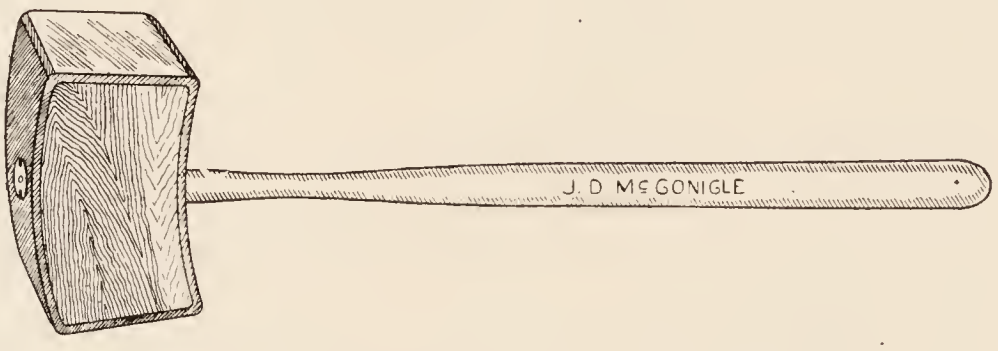


FIG. 69.—Author's curved wooden head osteotomy hammer to effect full force of each blow. The handle is steel.

Bone-grafting.

The Underlying Principles of Bone-transplantation.—It has been demonstrated, that some of the less highly organized tissues, such as skin, fat, fascia, cartilage and bone, are susceptible of transplantation into similar tissue elsewhere, when detached absolutely from their original environment or even preserved at low temperature usually in normal salt solution over a considerable interval after detachment. Other tissues which are more highly organized, such as nerve, ganglia, muscle and parenchymatous structures do not possess the necessary vitality or viability to permit this (Figs. 70 and 71).

Certain tissues continue to grow for a time after organic or somatic death or, as we may express it, cellular life persists, certain cellular elements acting



FIG. 70.—Bone defect from osteomyelitis of tibia before grafting.

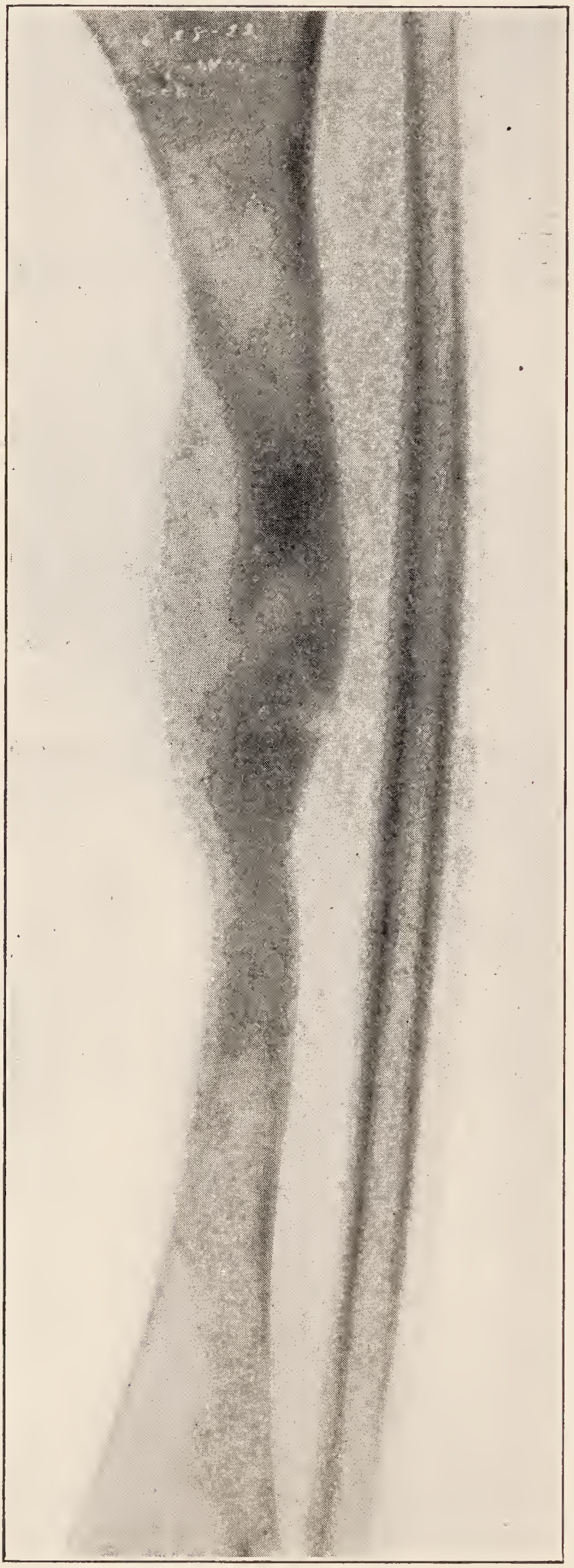


FIG. 71.—Same one year after bone grafting.

as a means for an independent existence as well as a source or nucleus from which new growth may occur. Bone, with its periosteum and endosteum, possesses this latter quality, which is known as *osteogenetic force*, showing itself in persisting viability, when transplanted into tissues supplying adequate nutrition by circulatory contact. All bone does not live and grow thus. When transplanted into another individual or animal or animal of another species, if the operation is aseptic and the contact perfect, it becomes an *osteoconductive* scaffold or framework in which osteoblasts may lay down new bone and bridge a gap, growing in from the host bone, which has received the transplant. This transplant does not grow and is ultimately absorbed.

Such is not the case with bone transplanted from one part to another part of the same individual's body or what is known as an *autogenous graft*, for it grows of itself from the bone cells adjacent to the periosteum and endosteum and it is therefore most important, in order to secure the most perfect success in a bone graft that these structures be retained as part of the transplant. It is now believed and generally thought that the proteid elements, tissues and fluids of one individual or animal differ from another and vary in degree and what we may call a foreign proteid, irritates or is not tolerated when transplanted into another individual or animal.

When such a transplantation is made from an animal of the same species, it is known as an *homogenous* or *homoplastic* graft and the nearer the relationship and racial connection, the more likely will the chances be of a "take," but none can compare with the autogenous graft, in this respect.

When a graft is obtained from another species of animal it is known as a *heterogenous graft* and rarely makes a successful transplant, as it is absorbed or extruded as a foreign body. It does not possess the proper elements to promote proper nourishment, is slow in stimulating repair and degenerative changes take place rapidly.

Boiled, sterilized beef bone, ivory and other substances have been tried and found inadequate to secure the best results. The life and future development of an autogenous graft seems dependent chiefly on the underlying bone cells or osteoblasts of the periosteum and endosteum, as has been previously stated, at least to give the more rapid and surer end results.

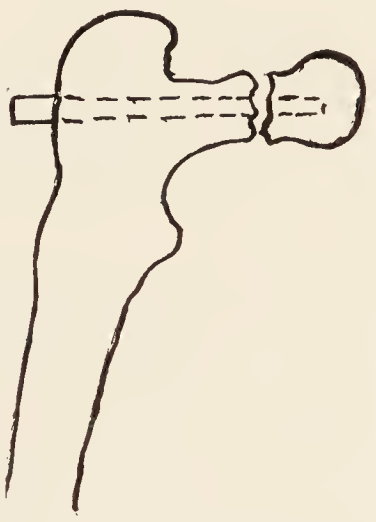


FIG. 72.—Tibial dowel graft in drill hole driven through trochanter and into femoral head; Albee method.

Bone-grafting may employ the inlay, the dowel, the wedge and the intramedullary methods. Of these, the inlay is the most commonly employed in that it brings identical histologic structures opposite one another and favors close contact. The numerous failures reported from intramedullary bone grafting is probably explained by the very absence of this histologic coaptation of like tissues and layers of the graft and host bone and besides that the medulla is often reamed out to receive the graft and many osteogenetic endosteal cellular elements are removed. The dowel is now employed chiefly to hold a larger fragment to a small one, such as the head or epiphyseal end of the femur to the shaft or diaphysis by a dowel driven through the Trochanter Major (Fig. 72).

The wedge-graft is used chiefly in uniting fractures in small bones and is sometimes employed as a double wedge, i.e., wide in the centre and spikes on each end. (See Reconstruction of the Hand.)

Doctor Henderson of the Mayo Clinic uses *large partial* inlay grafts as splints as well as to expose extensive osteogenetic surfaces to each other.

Bone-grafting has been perfected by the technique and ingenuity of Doctor Fred. H. Albee of New York, who has introduced many new procedures and devised an electric motor driven saw, dowel-maker, drill, et cetera, which greatly facilitate these operations. His instrument is equipped with twin circular saws, so that the gutter made in the host bone is identical in width with the graft and assures exact fit and close coaptation of identical structures. (Albee, Orthopaedic and Reconstruction Surgery, W. B. Saunders Company, 1919.)

The use of wire or other metallic substances, such as screws, bolts and plates in bone, produce atrophy and absorption and may ultimately be extruded or have to be removed as foreign bodies, so that these means of holding bone fragments together are becoming more and more obsolete, being replaced by autogenous bone-grafting and suturing, through properly placed drill holes, with kangaroo tendon. Exception to this is in oblique fractures of the tibia, fibula, radius and ulna, where temporary use of screws is the best method of treatment (Figs. 170 to 176).

Albee gives the following indications for bone-grafting: "(1) To immobilize and stimulate osteogenesis in certain tuberculous joints.

2. To repair traumatic bone injuries.

3. To replace bone destroyed by infection.

4. To supply bone congenitally absent.

5. To strengthen or replace bone weakened or destroyed by benign or malignant growths.

6. To correct congenital or acquired deformities of the face.

7. To establish joints congenitally absent and restore those destroyed by disease.

8. To fix in place certain dislocated joints (acquired or congenital).

9. To close bone foramina in neuralgias.

10. To correct congenital or acquired deformities of extremities or trunk.

More specific indications for bone-grafting are: (1) To immobilize support, and stimulate repair in spinal vertebrae whose bodies are infected with tuberculosis or other chronic infection where mechanical treatment is indicated. It is also applicable in cases of persistent non-union following fracture of the spine, presenting pain, disability and increasing deformity, and should be inserted as for Pott's disease. Further indications are for certain fresh fractures of the spine, spondylitis traumatica (Kummel's disease) and neuropathic spine (Charcot) where, on account of a rarefying osteitis, crushing of the vertebral bodies and increasing deformity is likely to produce cord compression.

2. In the support and immobilization of cases of tuberculosis of the sacro-iliac joint, in certain desperate cases of tuberculosis of the tarsus, and in the form of inlays to hasten or insure bony union in erasure or excision operations for adult tuberculosis of the knee or hip.

3. In certain cases of paralytic scoliosis to support the weakened spine and prevent lateral deviation due to superincumbent weight and unbalanced muscle pull.

4. To immobilize and support or replace bones of the tarsus destroyed or partly destroyed by tuberculosis.

5. To correct deformity or restore balance in congenital club-foot and acquired deformity from local disease or paralysis.

6. As a substitute for all metal plates, screws, nails, spikes and wires, as used in the internal fixation of fractures and other conditions. The graft, in the form of inlays and various sizes of nails or pegs, is employed by the author in all types of fractures, such as fresh and ununited fracture of the long bones and of the neck of the femur.

7. To produce permanent closure of nerve foramina after nerve section for neuralgia (Kanavel).

8. As a preventive of luxation or slipping of the patellae, by raising the low femoral condyle by inserting a graft in the form of a wedge.

9. To aid, by means of numerous small grafts, rapid bone union where joint resection has been done or where a large graft has been used.

10. To strengthen the spine and prevent lordosis or other deformity in cases of spina bifida, where a large amount of bone is congenitally absent.

11. To replace the head and neck of the femur when previously destroyed by disease, the head and neck of the astragalus being used as a graft (Roberts).

12. In congenital and paralytic dislocations of the hip where the acetabulum is shallow and the femoral head will not stay in place. The upper half of the meagre rim of the acetabulum is separated with a chisel and forced out and down, forming a pronounced rim. The cuneiform cavity thus produced is filled with wedge grafts.

13. To produce ankylosis of the ankle joint in severe paralytic cases or tuberculosis of the adult, by placing a bone-graft peg through the os calcis and astragalus into the lower end of the tibia (Lexer).

14. To replace bone removed for osteomyelitis, tuberculosis and spina ventosa.

15. For deformities of the nose, by contacting graft with nasal bones. If the skin incision is made in the tip of the nose, the scar is not noticeable.

16. To replace or repair defects of the lower jaw; to fill in sunken defects of the face, in the forehead, following operation; in bony defects due to tuberculous osteitis of the facial bones; in recession of the superior maxilla due to hare-lip; to replace a mastoid process removed by operation.

17. In intra-articular fracture-dislocation, the head of the humerus or femur, et cetera, should be replaced at an open operation, as a graft.

18. To repair cavities in the cranial bones by transferring from the immediate neighborhood one or two segments of the external table covered with periosteum. The cortex of the tibia or a portion of the scapula may likewise be used; the latter source is preferable, as both surfaces of the graft are covered with periosteum.

19. As an aid in arthrodesis operations, the use of fragmental grafts (bone seed) and dowel pegs of bone has been found valuable."

In conclusion, after an extensive war experience, as well as in many ante-bellum and post-bellum operations of bone grafting, the writer has found it an essential in securing a "take" to have the graft larger and longer than the gutters in the host fragments, so that it must be driven or sprung in. This procedure was devised by Major Gavin Hamilton of San Antonio, Texas, and

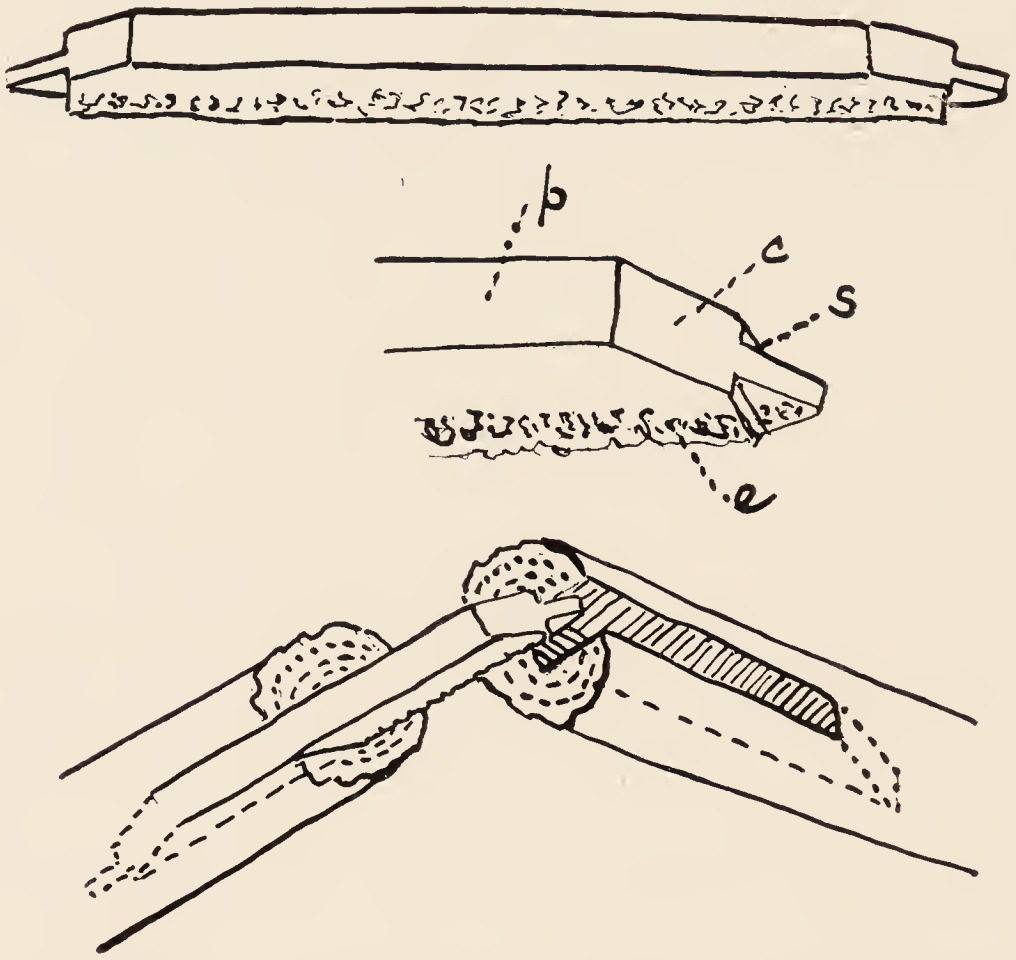


FIG. 73.—Gavin Hamilton method, mortised inlay and intra-medullary graft.
p = periosteum; *e* = endosteum; *c* = cortex; *s* = shoulder.

has been used by him and by the writer with a larger proportion of successes than with any other method (Fig. 73). A simple or loose inlay is often a failure. The graft should hold the fragments in line and not have to be wired or "Kangarooed" in place. It should be cut obliquely to extend well into the medullary cavity. "Bone seeds" are of little or no good in the author's experience.

CHAPTER XI

THE APPLICATION AND CARE OF BRACES

General Considerations.

Braces are applied to patients for four chief purposes: (1) to preserve the alignment of the body, limb or part; (2) to support the body or weight of the body on the lower extremities; (3) to produce leverage to correct a deformity; (4) to effect traction and overcome muscle spasm.

Braces to Preserve Alignment.

Under this category fall chiefly those used to maintain the normal carriage of the trunk, which from paralysis, weakness or habit deviates from the vertical normal, upright position to an antero-posterior deflection or lateral distortion or a twisted carriage (with relation to the pelvis) or a combination of all of these. As a rule, a well-made and scientifically applied plaster jacket, taking its secure foundation from well down on the pelvis, will meet the needs, but in intelligent patients a thoughtfully designed and fitted steel brace may do so and in a warm climate be more comfortable. If a brace is used, it must be held in place by an apron over the chest and abdomen or by straps through axillae and perineum and over the front of the body. The application of these will be more fully discussed under leverage. Alignment is sought in fracture also by plaster, braces and slings, as previously described; in slowly uniting fractures of the lower extremities to prevent deviation supporting steel splints should be employed until union becomes firm (Fig. 74).

Alignment is preserved by braces for such paralytic conditions, as paralysis of the hamstrings in the legs, to prevent the knee from bending backwards; also in "foot drop" and "wrist drop" until such time as the Tibialis Anticus and Extensors of the toes or fingers, as the case may be, regain their tonicity. In certain instances a brace is required to hold the head erect when the muscles are paralysed or pull asymmetrically (Figs. 75A and B).

Supporting Braces.

Braces used to take the place of muscles totally or partially paralyzed whether in the trunk or lower extremities and which combat the action of gravity or overaction of opposing muscles are termed supporting braces. Types in which they are applicable are one sided paralysis of the chest or abdomen, which would bulge to *that* side from lack of support or total flaccid paralysis of the legs which collapse, when the patient attempts to bear weight on them, if unsupported.

Supporting braces for the legs must be equipped as a rule with joints, corresponding to the centre of motion at the joint proper, to facilitate walking and sitting down. The centre of motion of the hip joint should come ½ an inch

above and anterior to the Trochanter Major, as the head of the bone projects upward and forward. The centre of motion of the knee joint should come about the centre of the femoral condyle, as the lower articular surface of the femur is

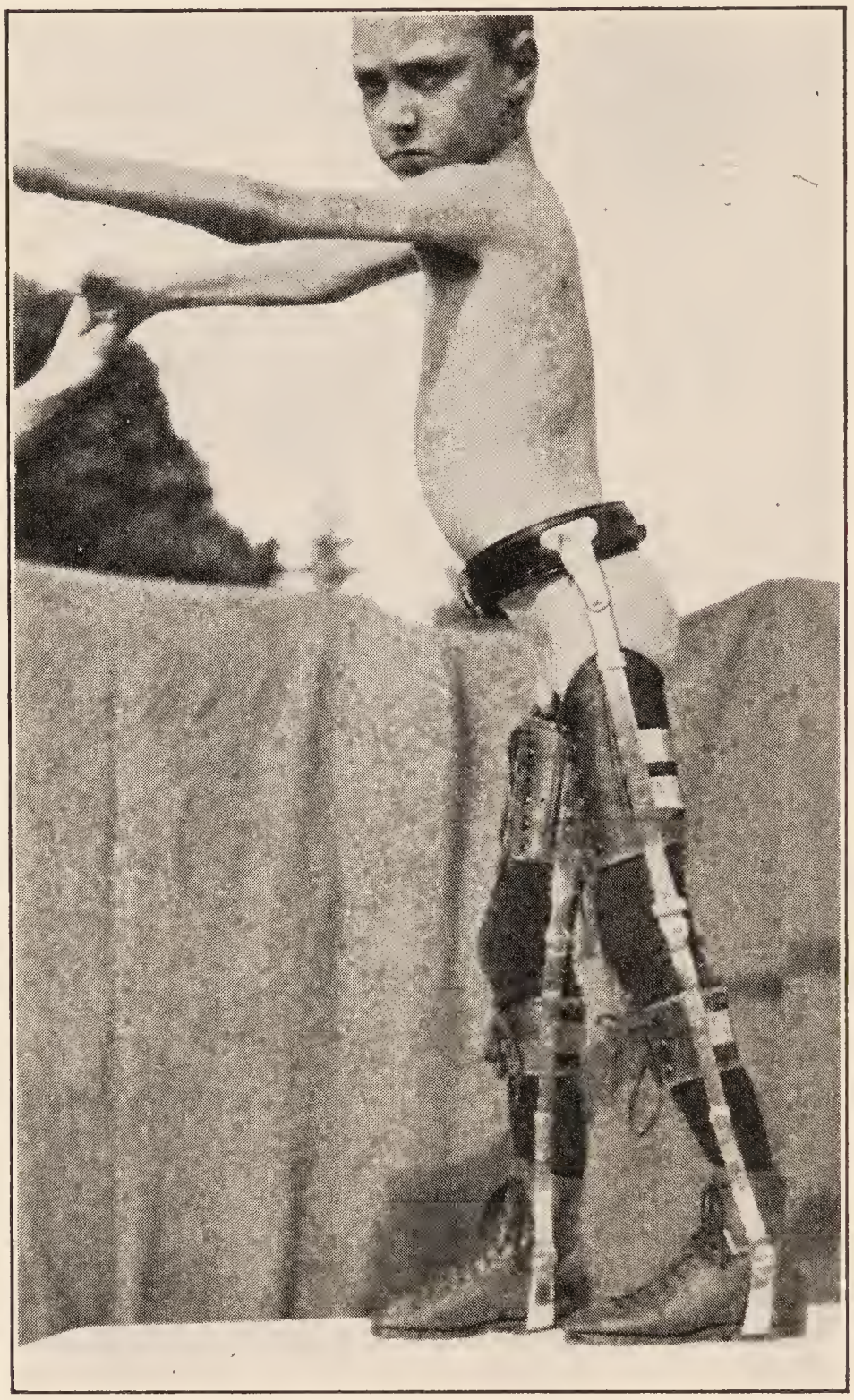


FIG. 74.—Paralytic braces to preserve alignment and afford support. Note lock at knee and stop joint at ankle.



A *B*

FIG. 75.—The Robert Jones dorsi-flexed "Cock-up" splint for wrist drop to aid grasp. *A* and *B*. (*Binnie.*)

convex downward. The centre of motion of the ankle joint requires special attention as the astragalo-tibial articulation is directed forward and outward.

Therefore, the inner joint in a brace with double uprights should be about a quarter or ½ an inch further forward than the outer joint, which in turn should be a ¼ or ½ an inch nearer the sole of the foot, than the inner joint, as it will be found that the outer articulation is on a lower and posterior plane to the inner and as the astragalus has a superior articulation surface, which is convex upward, both joints in the brace should be ½ an inch below the malleoli (Fig. 76).

These joints are either "lap joints" where one piece of metal laps over and is bolted to the other or "male and female joints" in which one segment is single and the other (usually the upper) is double and bifurcated, into which the single segment fits and is bolted(Figs. 77 and 78).

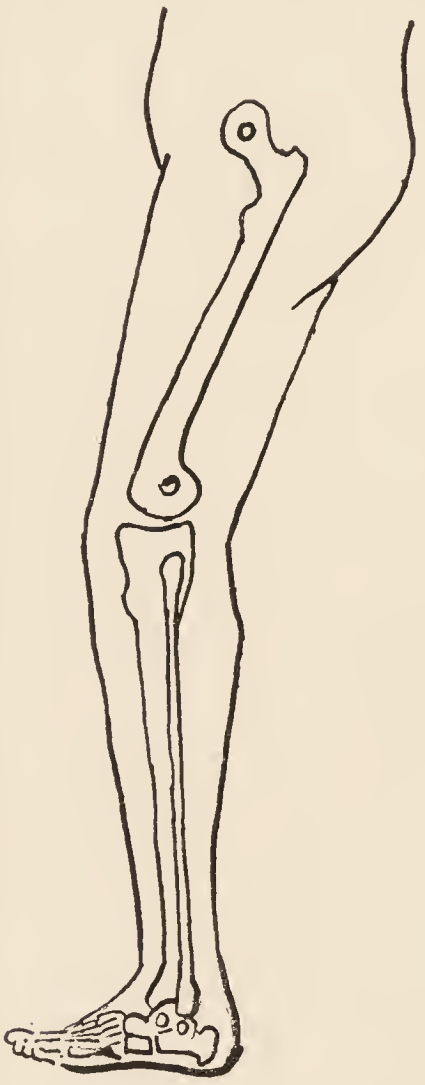


FIG. 76.—Centres of motion of hip, knee and ankle.

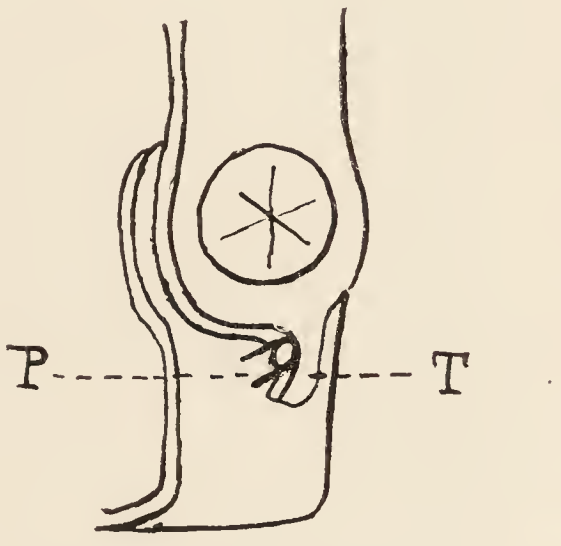


FIG. 77.—Lap "Stop-joint" ankle support. *T* = tongue. *P* = pin.

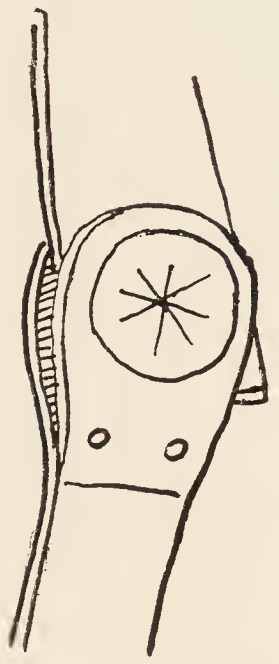


FIG. 78.—Male and female stop-joint, ankle or knee.

Anyone having the care of braces, whether nurse or parent, must realize movable metallic parts must be oiled to move most easily, prevent rusting, wear and squeaking. Usually, one drop of sewing machine oil on each joint should

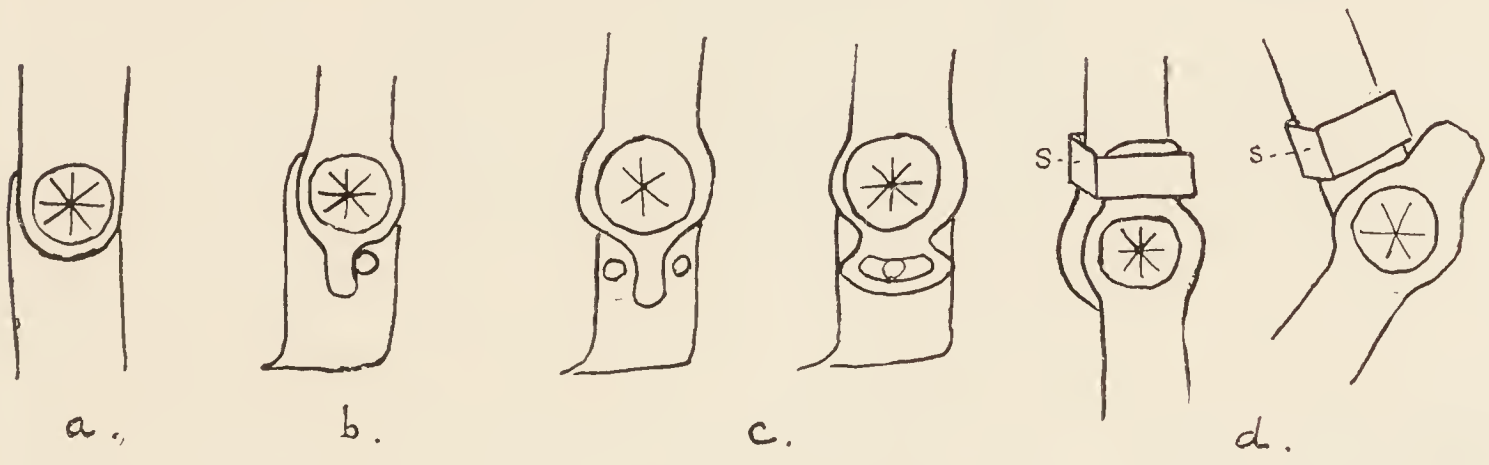


FIG. 79.—Various joints.

a, Free joint; *b*, reverse stop-joint; *c*, limited stop joints; *d*, lock joint. *s* = steel slide.

once daily be well worked in and any excess wiped off to protect clothing from grease spots. This will keep braces useful and easier on an already hampered patient. An immobile or stiff joint is a hinderance, rather than a help.

In addition to these two general types of joints, certain braces must be provided with devices also which prevent motion entirely when weight is borne, but permit motion when the patient wishes to assume a sitting position and are known as "lock joints." Certain others that permit motion in one direction and not in another are known as "stop joints" and those which permit partial motion in two drections are "limited stop joints" (Fig. 79).

A lock joint may be obtained in a lap joint by having a tongue of the lower element projecting upward above the joint and around this tongue and the upper element, a metallic strap or ring fits. By lifting the ring or strap with the hand the joint may be flexed, but when the limb is again fully extended the ring automatically drops in place by gravity and locks the two elements (Figs. 79D and 80).

Another type of lock joint consists of a spring-controlled handle projecting upward like a leather-punch attached to the upper element, on the end of which is a pin penetrating both the outer and inner lap joint elements, when the limb

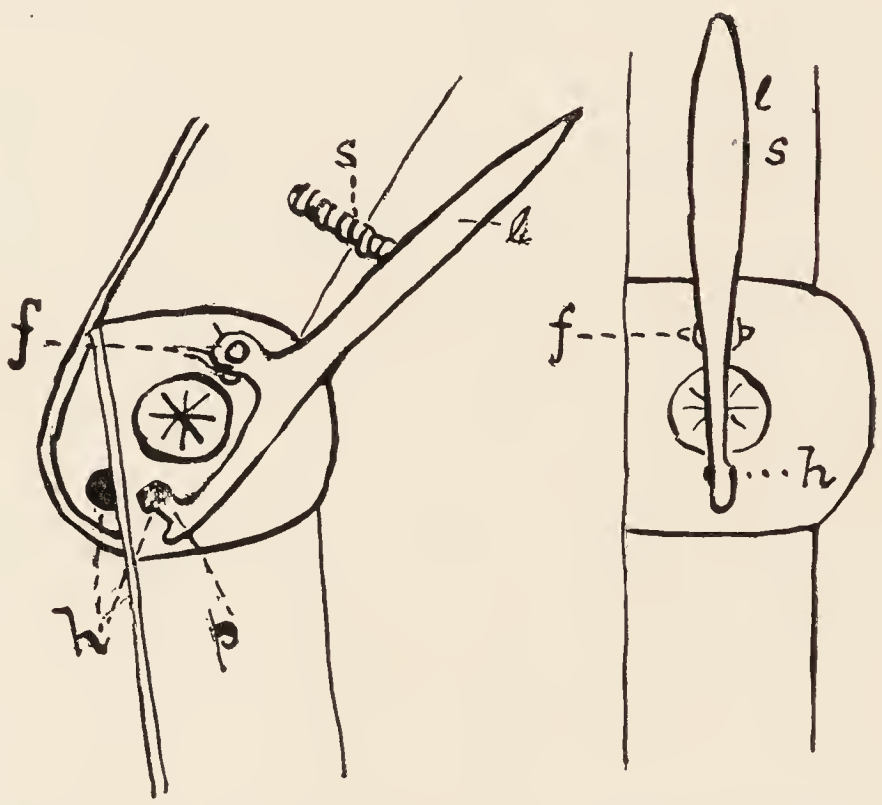


FIG. 80.—Automatic knee spring lock-joint. Not released until lever is pressed. *s* = spring. *l* = lever. *f* = fulcrum joint. *p* = pin. *h* = hole in plate. When extended pin drops automatically in hole.

is fully extended, but when the handle is pressed and the joint flexed by gravity or muscle action the terminal pin impinges on a quadrant of steel attached to the inner element and the brace is unlocked. On full extension, however, the spring actuated pin comes opposite the hole in the inner element the spring effects an automatic locking. These last two are employed chiefly at the knee.

In the male and female type a stop joint may be provided by having the male element made with an angular and not round end, either forward or backward, as may be desired, which will impinge on the female element to prevent motion beyond this point.

In the lap joint the outer element may be provided with a tooth and the inner with a steel peg, so placed that when the tooth strikes it, further motion is prevented. In ordering a brace the surgeon must specify, of course, whether this motion is to prevent forward or backward motion and the type of joint desired, i.e., whether lap joint or male and female.

"Limited stop joints" may be obtained by having a steel peg centrally located on the inner element and a bidented or forked outer element fitting over the peg to permit a little motion in each direction. Or the outer elemen- may have a curved slot into which the peg fits, which will permit motion depent dent on the length of the slot.

Many supporting braces with double uprights for quadriceps paralysis will be seen, which permit flexion at the knee in spite of lock joints at the knee, when the weight is borne. These *misfits* are due to the calf and thigh steel bands being too shallow and not permitting the lateral upright to come *anterior* to the centre of gravity line of the leg, i.e., *anterior* to middle of the centre of the side of the knee (Fig. 81). As an additional help for this trouble, the upper and

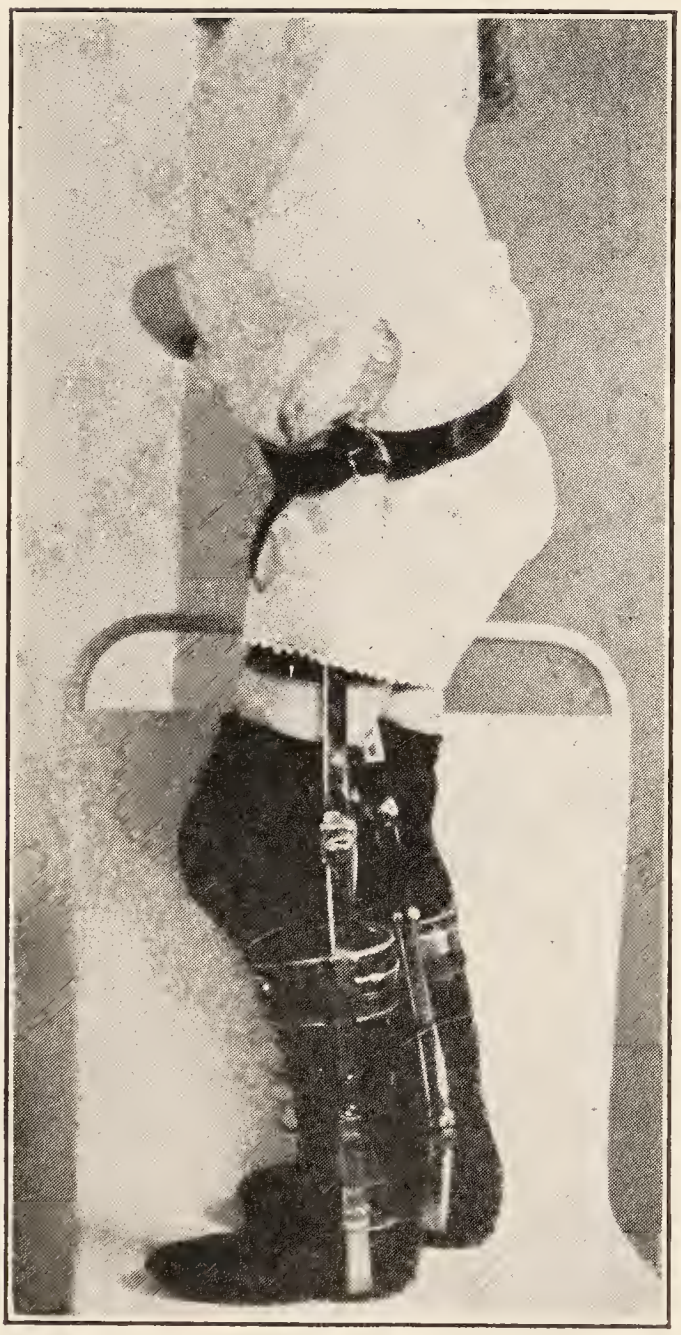


FIG. 81.—A misfit.

lower elements may be curved backward at the knee joint to throw the centre of motion backward as well as above the articulation.

In order not to cause a groove in the muscles from pressure atrophy in the thigh and calf due to narrow bands in these regions, two or three posterior aluminum, german silver or steel bands should be used with padded leather laced cuffs surrounding the thigh and calf *over as wide an area* from above downward as possible to give greater support and produce less atrophy.

Leverage Braces.

Braces to produce leverage are used chiefly to correct curvatures in a bone or series of bones. Thus we will find their application more often in backward or forward curves of the spine and in bow-legs and knock-knees. In tuberculosis of the spine, where the focus of disease affects the bodies of the vertebrae, the bodies collapse and the spinous processes project backward causing hump-back, while the vertebra above, lacking support, sag forward and those below also sag forward from muscular and ligamentous pull and the change in the centre of gravity. The problem of the brace in this affection is to secure fixation and firm support at the pelvis with the fulcrum or greatest pressure at the hump; while above and below it, the brace should not touch, except when pulled back by the apron straps, which pass around the anterior portion of the body (Fig. 82).

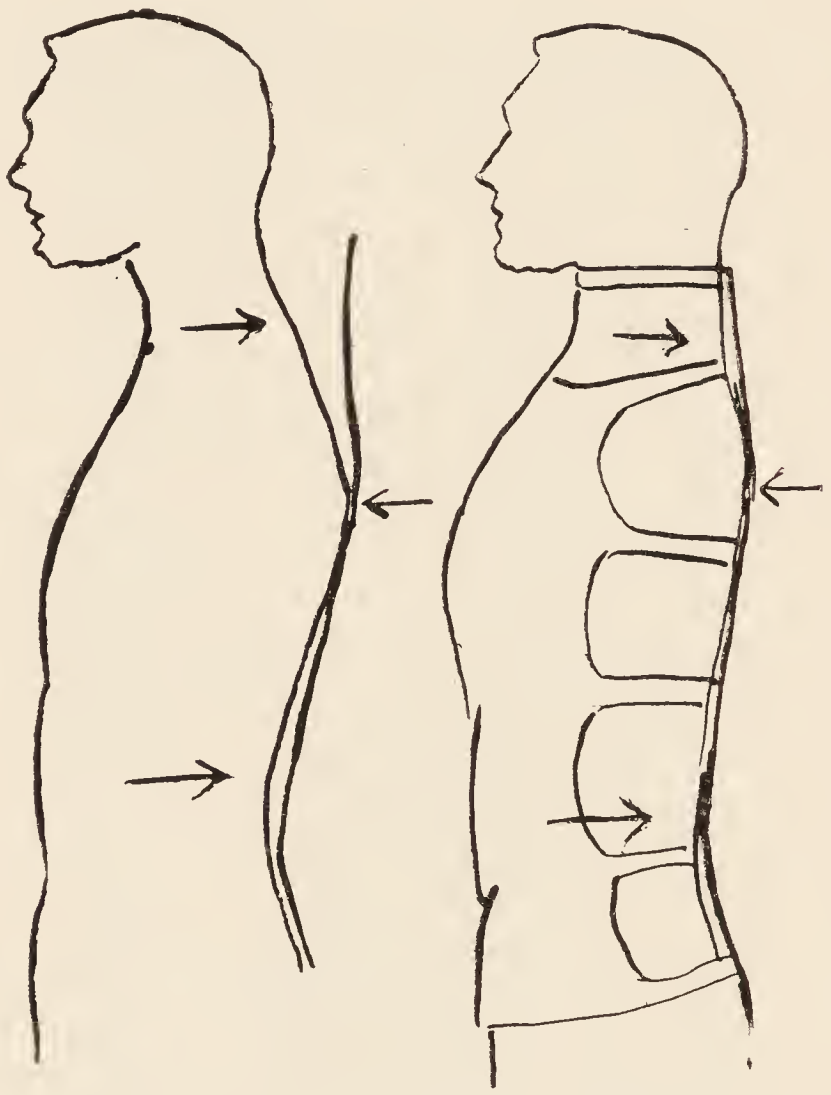


FIG. 82.—Leverage brace for Pott's disease and round shoulders.

To make a spinal-support apron, a pattern is made of newspaper, allowing for hems in the following manner: a piece of newspaper of sufficient size to cover the anterior surface of the body of the recumbent patient is folded lengthwise, to centre it from the inter-clavicular notch to the symphysis pubis. At the top a semi-circle is cut out at the throat and so that two projecting flaps or straps will come one inch above the clavicles, a curved piece is cut out to follow the curve of the shoulders and come about an inch below the axilla. Then a vertical cut is made down the mid-axilla to an inch or more *posterior to* and *below* the anterior superior spine. As assistant must then hold the pattern at the sternum and symphysis, while the sides are fitted by cutting in and pinning darts or putting in gussets. Occasionally darts must be put in at the top of the sternum and at the symphysis to fit absolutely smoothly. This pattern is

used to cut a double thickness of twill, which when fitted again to the patient is hemmed and sewed on the sewing machine, webbing straps being interposed between the layers in the top straps and on the sides where buckles come on the brace. The apron should cover the entire abdomen; otherwise, hernia may result if the lower portion is not supported. Axillary and perineal straps are made of webbing covered with canton-flannel (Fig. 83).

In round shoulders the problem is somewhat the same. The brace fits up to the forward sagging upper portion of the spine, from which point the brace stands off from the back, except when the straps are fastened to hold the spine erect.

In bow-legs, a steel upright is employed on the inner side of the leg fastened to the shoe and with a pad at the knee or a cuff at the groin depending on whether the lower leg or whole leg is to be straightened. Cuffs are then adjusted as tight

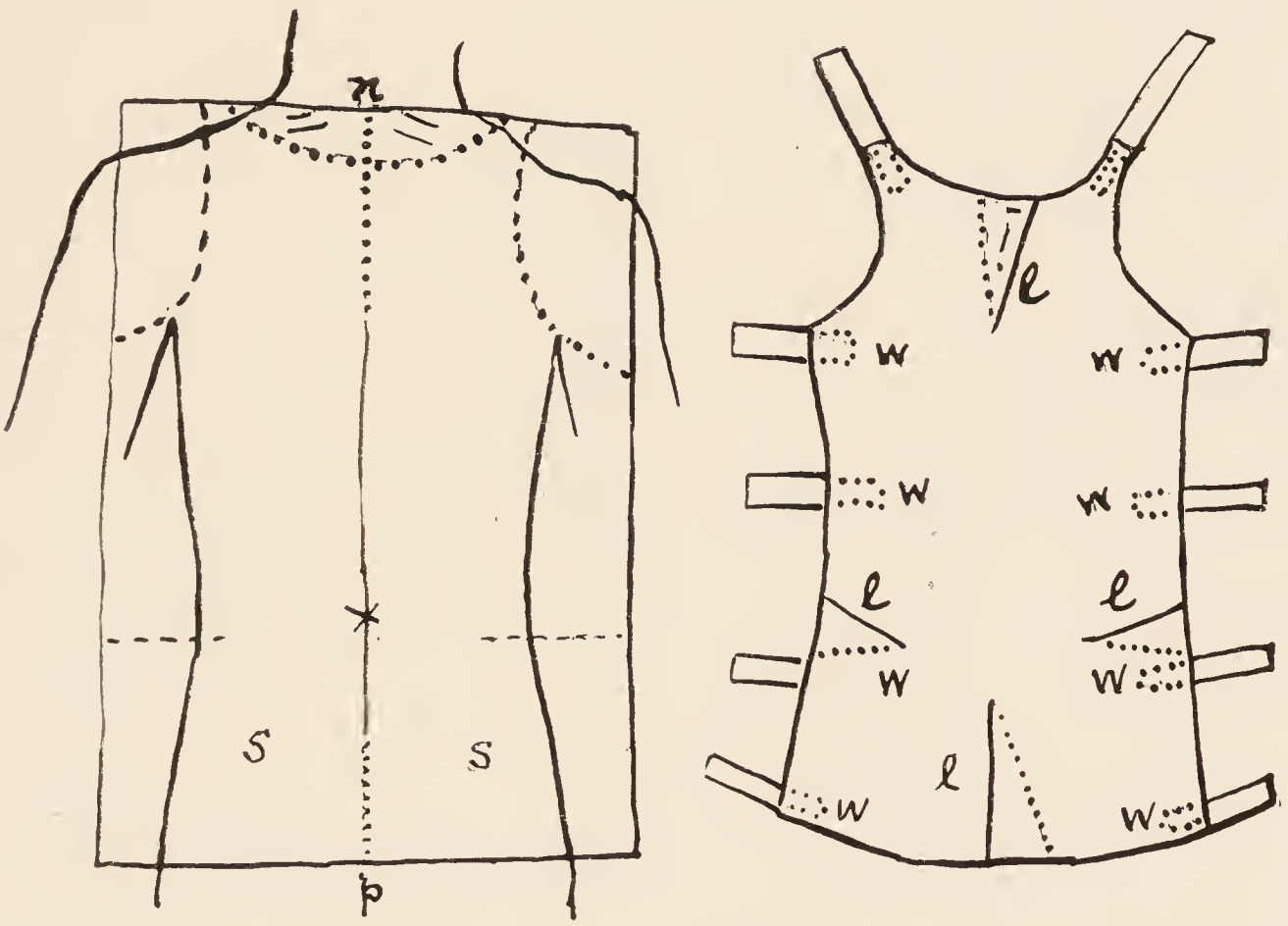


FIG. 83.—Making a paper pattern for and fitting an apron.

a, Paper pattern folded down centre from interclavicular notch to symphysis pubis and cut down dotted lines. *n* = notch. *s* = anterior superior spines. *p* = pubis; *b*, completed apron lapped and sewed at *l*. *w* = attachment of webbing straps between the two layers of twill apron.

as desired around the leg at the apex of the curve and the steel upright. In knock-knee a similar arrangement is employed on the outer side of the leg to pull the curve *towards the brace* (Fig. 84).

Another type is a convex steel spring with cuffs and a pressure pad to go against the apex of the curve on the convex side. In bow-legs this is attached to the outer side of the leg. When this is strapped to the leg, the *curve is pushed away from the brace.* The same arrangement is employed for knock-knee on the inner side of the leg.

Traction Braces.

This form of brace finds its application chiefly for Tuberculosis of the Hip and Knee Joints and in upper Cervico-Dorsal Tuberculosis of the Spine to

overcome destructive muscle spasm, which crowds the pathologically softened bone against the healthy bone, thereby not only producing pain, but causing extension of the disease.

The types of hip or knee traction splints must have a base or fixed point from which pull can be made at the Ramus of the Pubes and Tuberosity of the Ischium; this is accomplished by a leather padded ring of steel attached to lateral uprights or by slings from the tops of two lateral steel uprights.

All of these types of braces have two lateral uprights that follow the outline of the leg and terminate two or more inches below the foot in a transverse foot piece. Just above the foot piece is a transverse rod with catches to hold ¾-inch webbing and on the outer side a spring-ratchet supplied with a key, so that

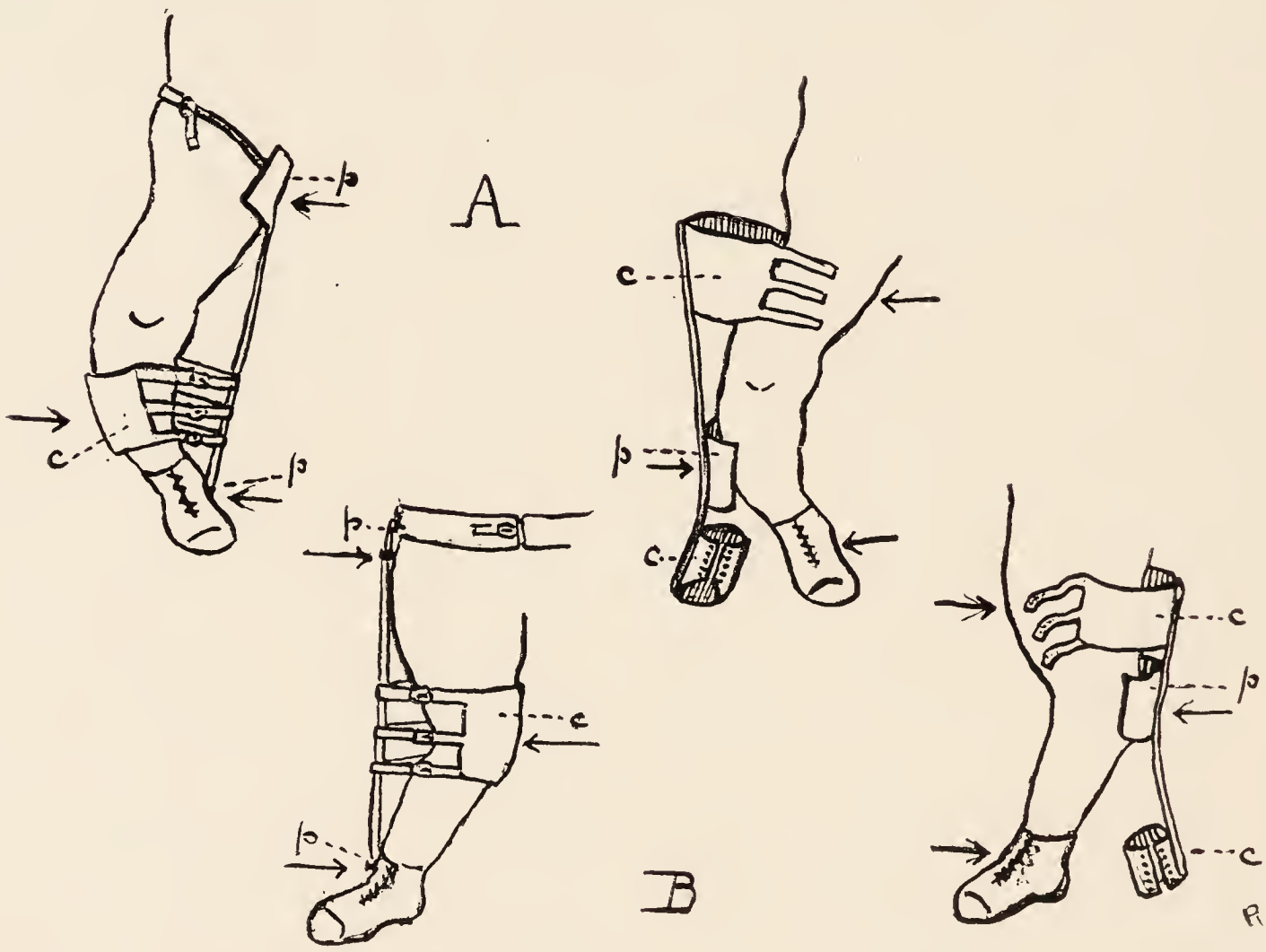


FIG. 84.—*A*, Bow-leg braces (push and pull); *B*, knock-knee braces; (push and pull) *c* = cuff. *p* = *pad*.

the webbing from the straps of a Buck's extension can be wrapped around the transverse rod and traction made by winding. In the case of hip disease, the Buck's extension straps extend well up on the thigh nearly to the groin, whereas in Tuberculosis of the Knee the straps should not extend quite to the knee (Fig. 85).

A frequently used type of traction brace has a pelvic band and two perineal straps buckled to it and an outside upright only with foot piece and ratchet.

If a pelvic band is used at the top of the brace, it should fit accurately around the pelvis below the anterior-superior spines and always be adjusted by buckling the perineal straps *first* to hold it at that level *before* winding the brace at the bottom. If the brace pulls too hard, the patient will complain of pressure at the groin; never, however, loosen the perineal straps to relieve this, as it will throw it out of adjustment, but *release the ratchet at the bottom* to relieve the pull

on the Buck's extension. If the perineal straps are too loose above, the pelvic band will slip up towards the waist and the ratchet-rod will come against the sole of the foot and not an inch or two inches below it, as it should, to permit traction of the leg downward. In war surgery, the type of brace with ring at the top and two lateral uprights is known as the "Thomas splint" and instead of the foot piece having a ratchet at the bottom, it is bent upward in the centre to permit tying a bandage which is fastened around the ankle and foot in a "clove-

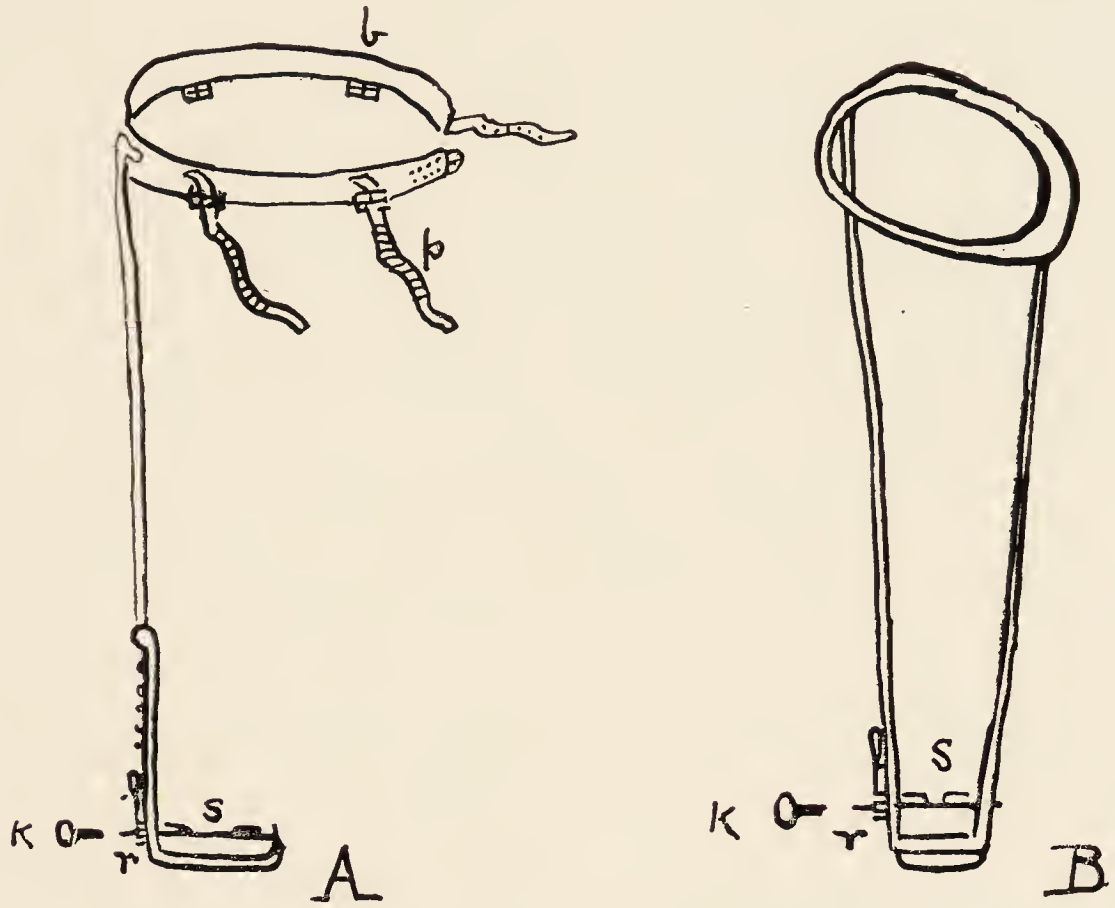


FIG. 85.—Traction braces. Taylor (*A*) and Thomas (*B*).

b = pelvic band. *p* = perineal straps. *s* = slots for traction straps. *r* = ratchet and windlass with spring lever. *k* = key.

hitch," carried around the uprights and twisted by a stick as a "Spanish windlass" to produce traction for simple and compound fractures. The Jones Rectangular Splint for fractures of the humerus is bent at a right angle at the elbow and is similar to the Thomas splint but possesses the advantage that trace tion can be made by bandages vertically as well as transversely to secur- alignment (Fig. 27).

CHAPTER XII

SURGICAL MENSURATION*

Many different methods have been suggested for making measurements for both military and civilian clinical records, and it is with a desire of obtaining a standardization of these that the present chapter is concerned, as well as to encourage recording by a simple method. In the majority of hospitals, no measured record of affected bones and joints is kept. In these hospitals the only instruments for routine anthropometric record are usually the tape-measure, the X-ray and possibly the photographic camera. In a small number of hospitals, chiefly orthopaedic, an endless number of devices are to be found, many inaccurate and unscientific, for measuring the range of motion or angle in joints. It can almost literally be said that no two of them use the same appliance for recording motion and each has a different apparatus for each joint in the body.

It is conceded that for the most thorough work, full bedside clinical records should be detailed on the chart, not only to give data as to the condition of a patient when first seen, but also to note progress under treatment and the end result. In the standardization of hospitals, proposed by the American College of Surgeons, full clinical records are insisted on.

It is advisable that any device adopted for recording motion should be of universal application to all joints to render use general, and not require one for each joint. The device should be simple in construction, inexpensive, and easy to use, so that the readings of different individuals should give minimum variations in the hands of the different observers, and thus the personal equation be eliminated, as far as possible.

Records Required.

Three and possible four comparative records are required in the involved and uninvolved extremities and joints on the two sides, viz: (*a*) length of extremities; (*b*) circumference of extremities; (*c*) motion of each joint; (*d*) position or angle of malposition in ankylosis or partial ankylosis. In the spine, deviations in an antero-posterior or lateral direction and limitation of motion in the different regions are to be recorded as to extent. The amount of rotation in scoliosis, as to degrees, is necessary for record.

It is essential for accuracy that a fixed position of the body be maintained for immediate and future observations. This can only be attained when the body is supine or prone, centred on a horizontal examining table with the extremities symmetrically placed, unless the disability itself prevents, except in determining pronation and supination of the forearm and motions at carpus, metacarpophalangeal and interphalangeal joints. In a standing attitude a patient may

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consciously and intentionally or unconsciously tilt or lean forward, backward, sideways or in a twisted position and no records at stated intervals should be made thus with any idea of accuracy.

Apparatus Required.

1. Table. An ordinary horizontal rectangular wooden top examining table, six feet, six inches long and three feet wide with legs three feet high is necessary. The centre of this table at top and bottom is marked with a thumb tack. An

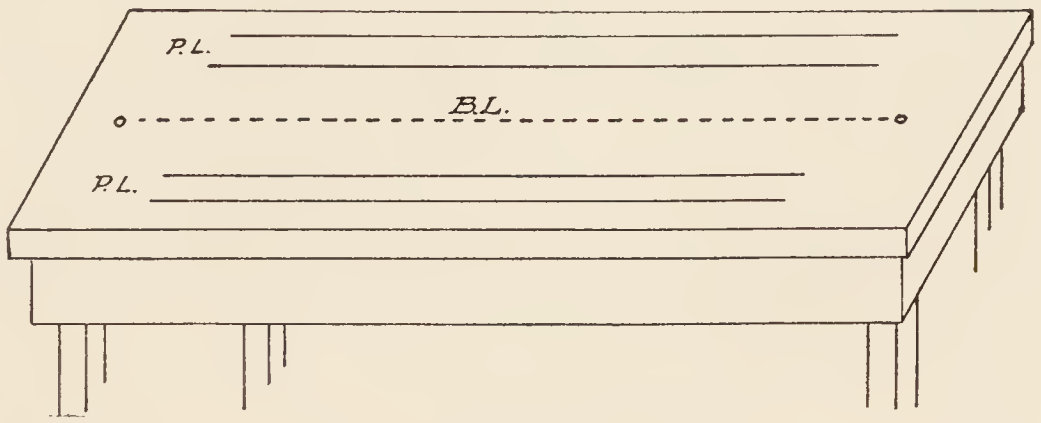


FIG. 86.—Examining table.
Bl = Base line. P = Parallel lines.

imaginary line joining these will constitute what we may call our base line. In the region that will correspond with the location of shoulder and hips of patients to be measured, two lines are ruled on each side parallel with the table's edge, and, of course, with the base line, and three inches apart. These we speak of as parallel lines (Fig. 86).

We know from geometry that when a line crosses two parallel lines, the alternate interior angles are equal and any line at right angles to the first line crossing the parallel lines produces also alternate interior equal angles (Figs. 87, *A* and *B*).

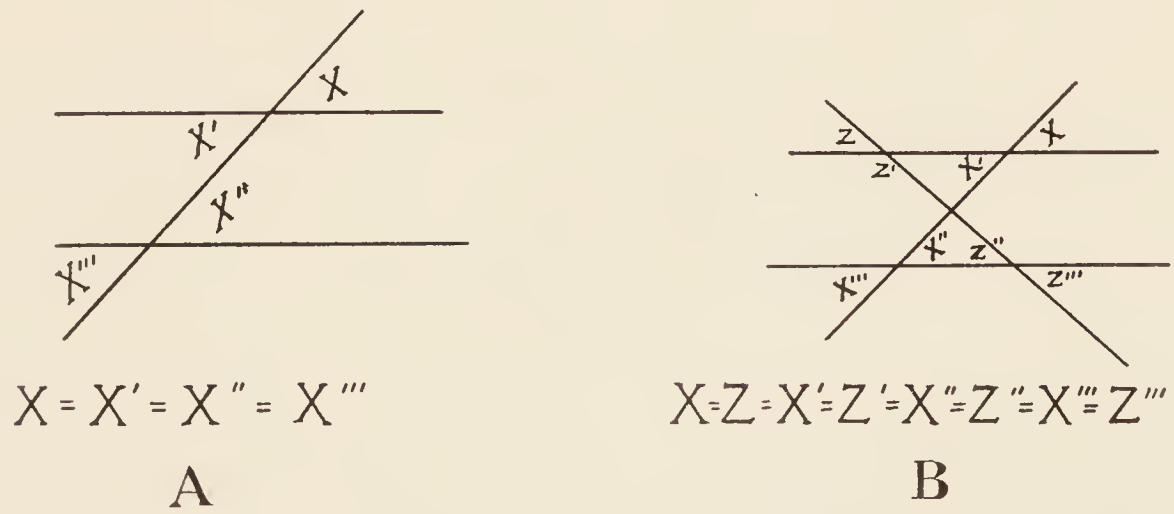


FIG. 87.—Geometric figures used as a basis for making the records.

Therefore, any angle made by an extremity in relation to the base line or upon which we have the axis of the patient's body or a joint resting, is identical with that angle obtained from the table's edge or any line parallel to it, when the patient is properly centred. Take for example, adduction of the humerus (Fig. 88). *AB* equals the line of axis of the humerus. The angles *BGH* and *BFD* are not measurable as the patient is lying on them, but the angle *ECA* (or *BCJ*) is identical and equal to them, easily sighted and accessible. It

would be manifestly incorrect to put any instrument on top of the rounded shoulder or hip, and expect to obtain an accurate reading. These readings,

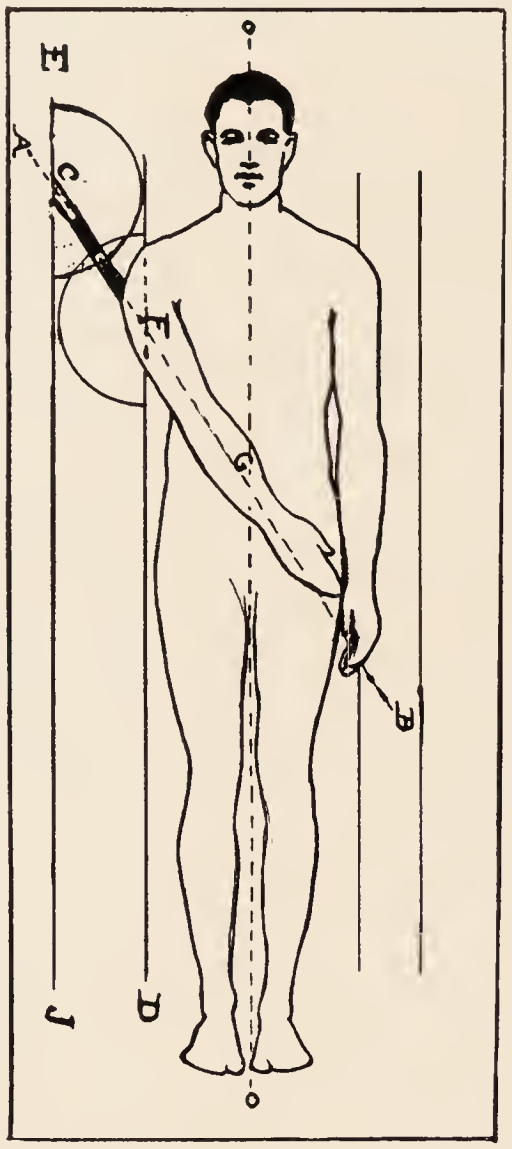


FIG. 88.—Measuring adduction of arm.

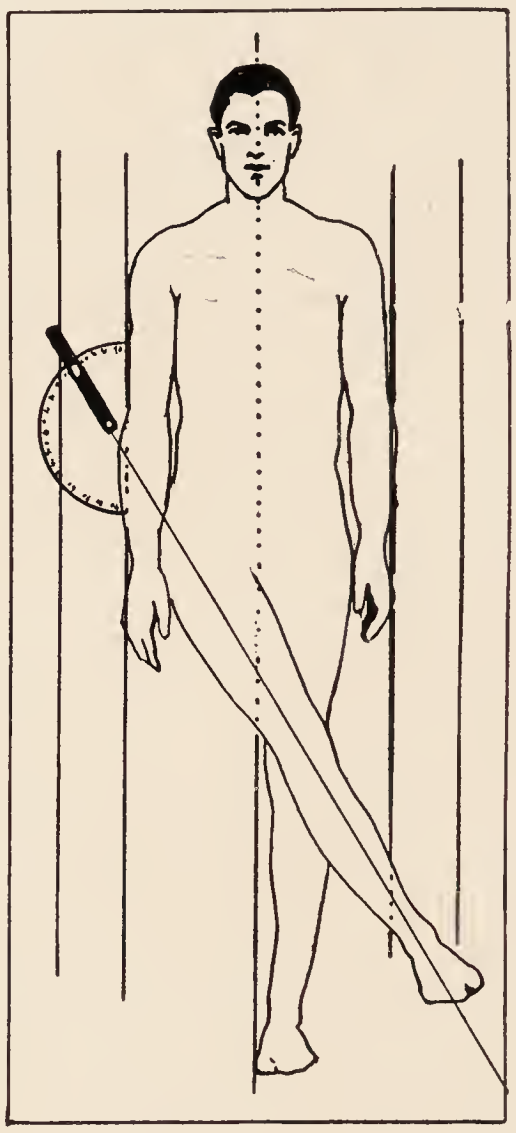


FIG. 89.—Measuring adduction of leg.

however, from the parallel lines are readily made by a graduated semicircle and protractor (Fig. 89).

2. The semicircle with a protractor at its centre is graduated in degrees to measure the range of motion. This is made of aluminum, and has two forklike

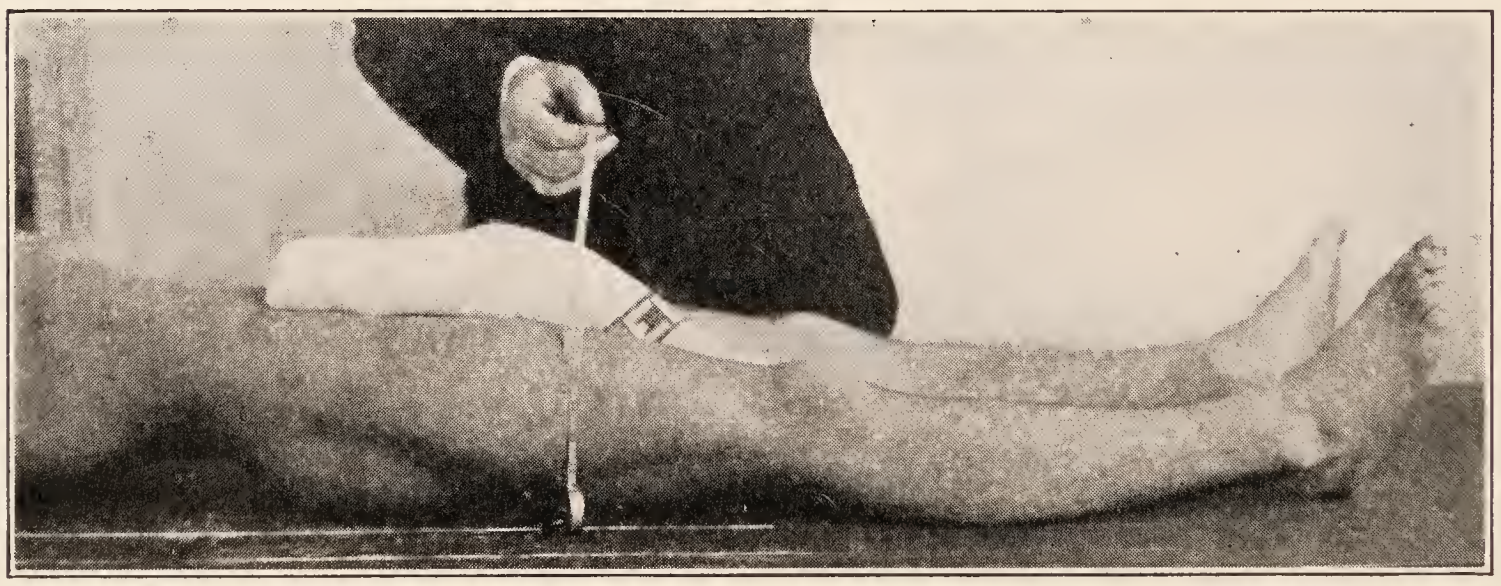


FIG. 90.—Using tape measure case as weight bob to secure uniform tension in measuring circumferential measurement.

legs, which may be attached, if it is desired to use it vertically (Fig. 92) as well as horizontally without them (Figs. 88).

3. The ordinary cotton spring tape measure. This is preferable to the steel tape measure, as well be seen under measurement of circumference (Fig. 92).

4. The lead tape consists of a strip of sheet lead 3 mm. thick, 2 cm. wide and 1 m. long, and is to be molded over curves and used then as a ruler to trace these data on the history (Fig. 91).



FIG. 91.—The lead tape being molded over a spinal curve.

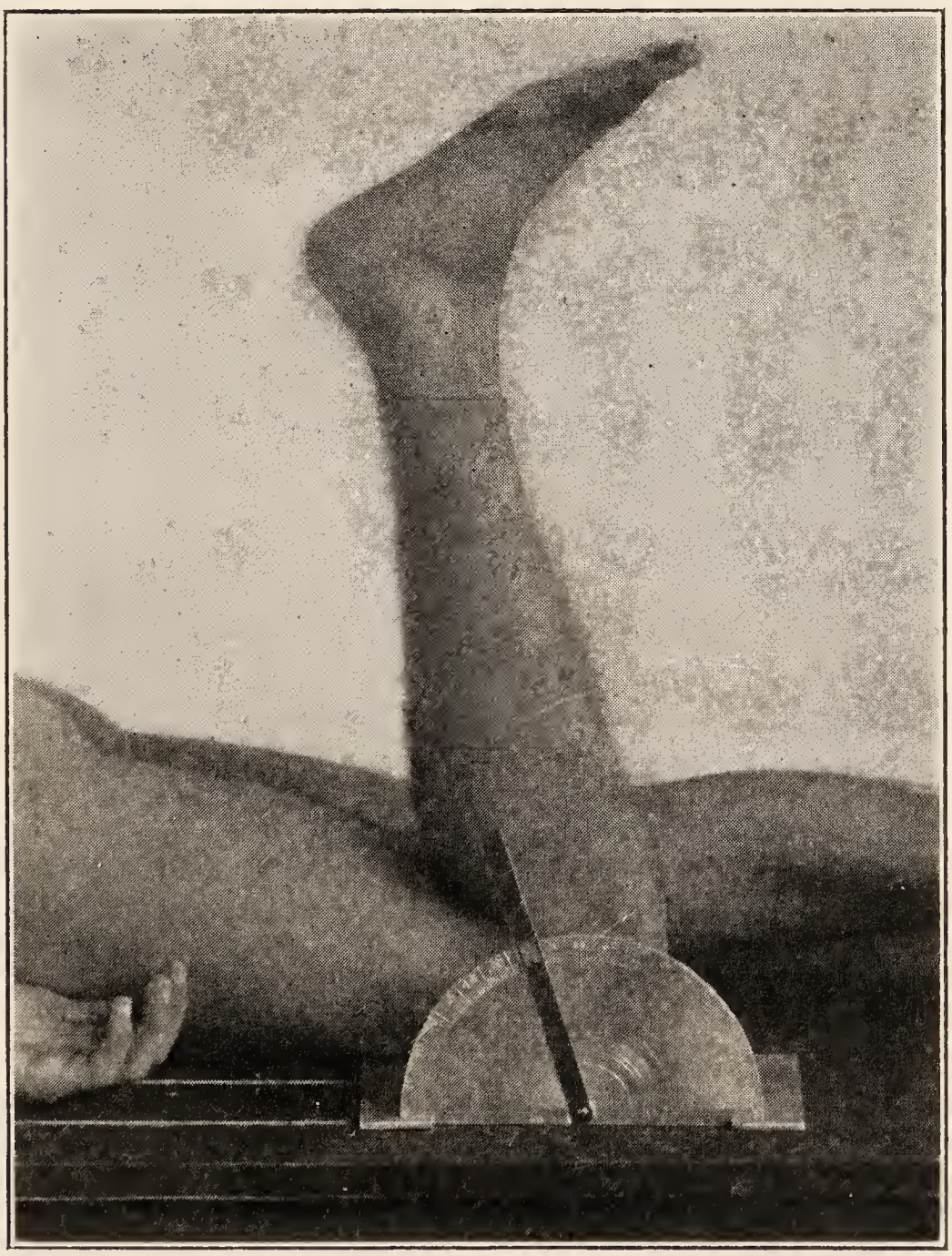


FIG. 92.—Method of recording flexion of the knee.

5. A rectangular drawing triangle.
6. A yard stick.

Standard Positions of Patients to be Measured.

In order that all subsequent measurements may be comparative, it is essential that a standard position be agreed upon in which all individuals are measured and as in all upright positions, inclination of the trunk in relation to itself or to the extremities are likely to vary, the position in recumbency becomes the natural standard.

Normal Position.

The centre of the table in the region of the head and the heels is used as the guide in placing the patient in the supine or prone position. The arms are to be at the sides, fully extended and the forearm in neither pronation nor supination, and the fingers fully extended. The line joining the anterior superior spines

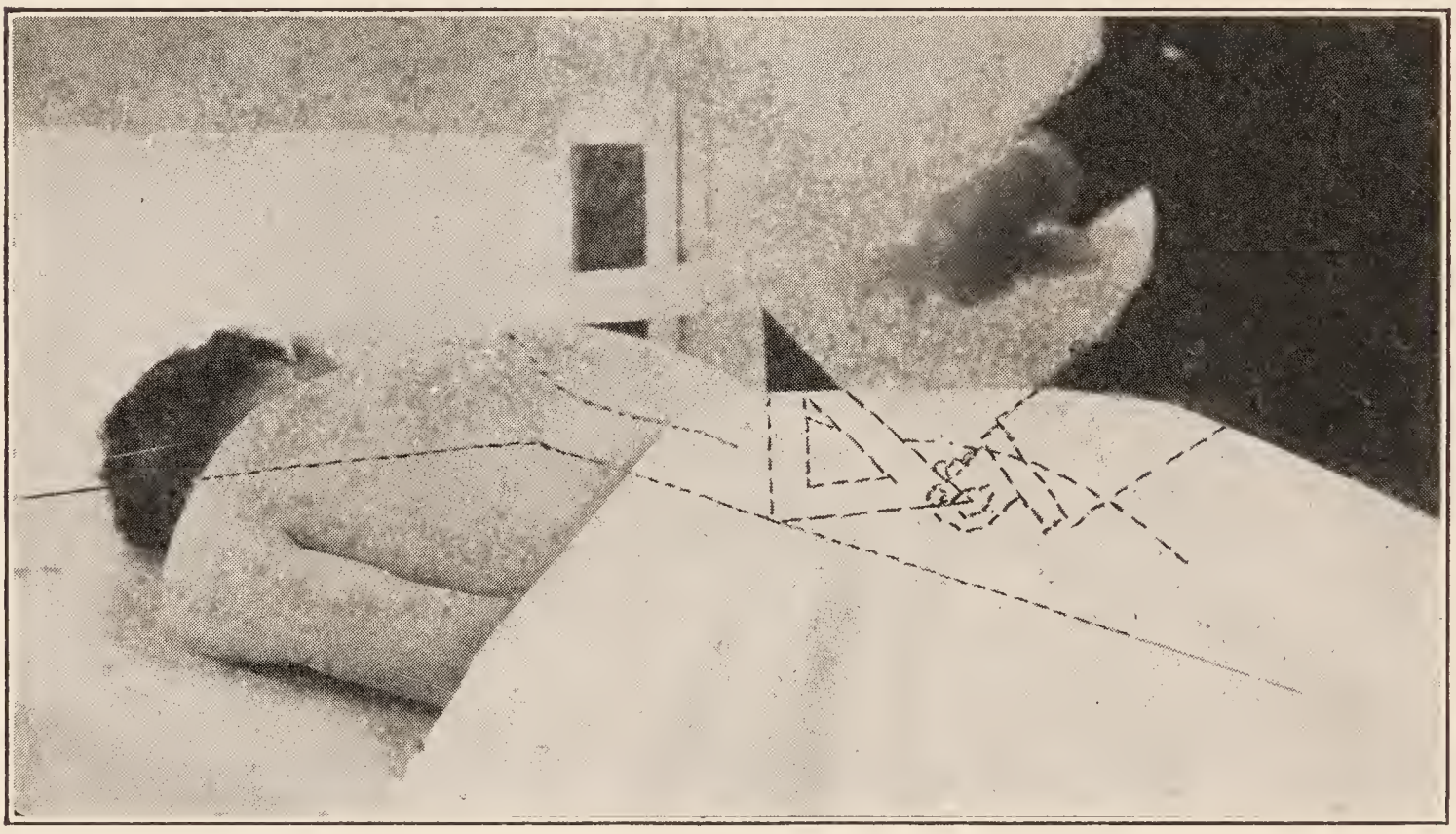


FIG. 93.—Method of measuring lateral curvature from edge of table by rectangular triangle and yard stick.

of the patient must be at right angles with the base line. The legs are fully extended with the toes pointed vertically upward, and the heels equally distant from the central base line.

For records of spinal deviation or knee flexion, the patient is similarly to be centred in the prone position. Figure 91 shows the recording angular deformity in Pott's disease by the lead tape, which is to be used as a ruler in tracing the curve on the history. Figure 92 shows method of recording flexion of knee. A method is demonstrated of measuring by means of yard stick and rectangular triangle amount of deviation of spine from base line in lateral curvature (Fig. 93). The patient sits beside the table with the entire forearm supported for records of pronation and supination with the semicircle vertical and beyond the finger tips and at right angles to the axis of the arm. Similarly, but with the semicircle flat on a parallel line flexion of the wrist and metacarpophalangeal joints may be measured (Fig. 94). The recording angle of rotation in scoliosis is demonstrated by yard stick and graduated semicircle and protractor. For recording Rotation of the Spine the yard stick is centred and placed trans-

versely across the spine and the semicircle placed on it with the protractor vertical and the reading made. For tests of flexion of terminal phalanges or second joints the palmar surface of the hand is placed on the table up to the joint and the reading made with the semicircle vertical and parallel with the finger.

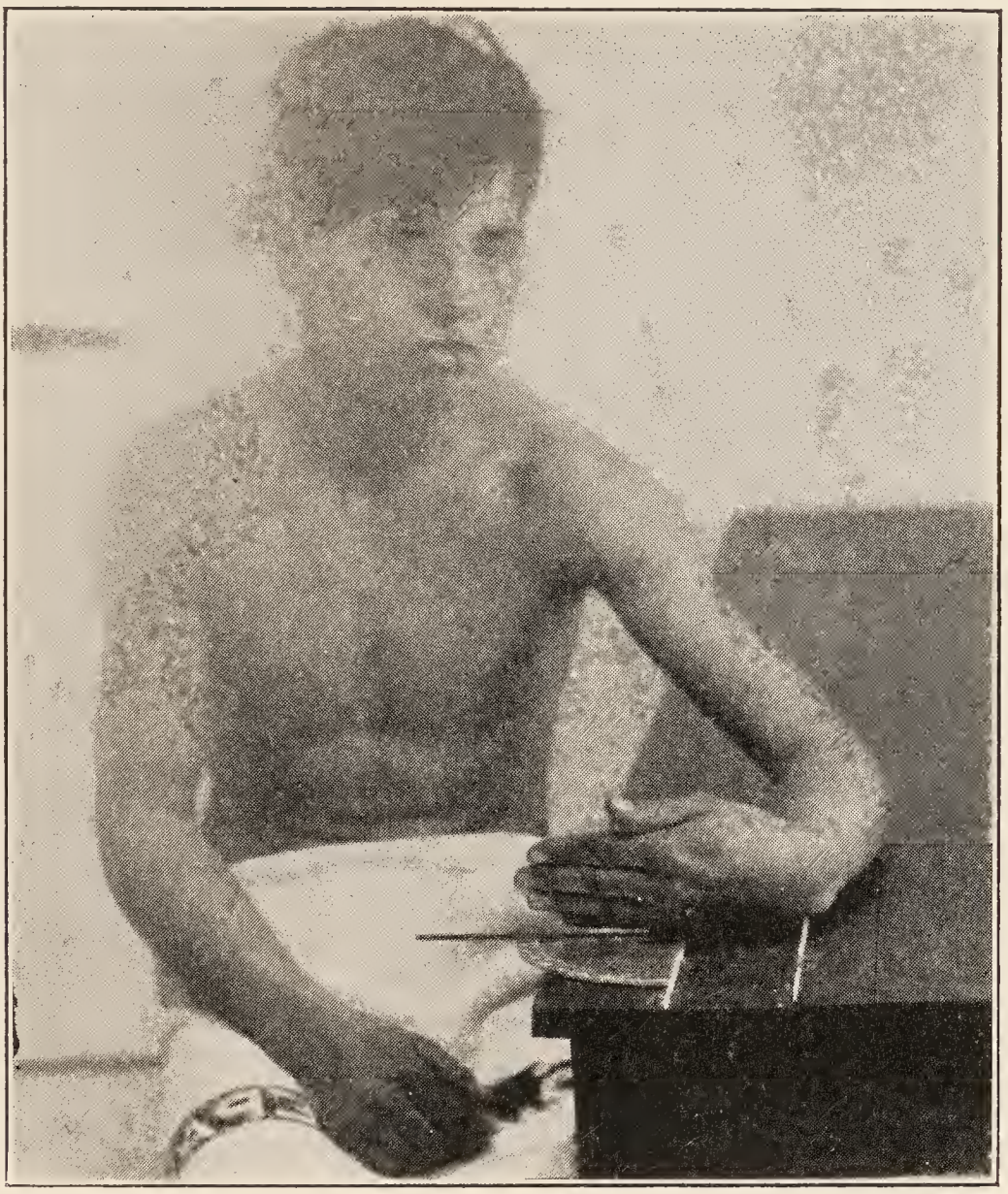


FIG. 94.—Method of securing readings of wrist flexion with entire forearm supported.

Landmarks.

The following landmarks are, as a rule, easily and accurately located in all individuals in order to measure length of bones: (1) Suprasternal notch;(2) tip of the xiphoid cartilage; (3) symphysis pubis; (4) anterior superior spines; (5) anterior tibial tubercles; (6) malleoli; (7) acromion processes; (8) olecranon processes; (9) styloid processes of the ulnae; (10) vertebra prominens; (11) posterior superior spines; (12) ischial tuberosities; (13) greater trochanters, and (14) gluteal notch.

When the patient is in position, landmarks 1, 2 and 3 are on the base line, and the line joining the two anterior superior spines should be at right angles to the base line. The distance from the anterior superior spine to the internal malleolus found on each side gives the comparative measurement of the two legs. If one is shorter than the other, and it is desired to determine the bone at fault, this may be done by measuring from the anterior superior spine to the anterior tibial tubercle and from there to the malleolus on each side.

Similarly the arms may be measured from the acromion processes to the styloid processes of the ulnae, and to and from the olecranons.

The anterior superior spine, the greater trochanter and the ischial tuberosity are normally on Nelaton's line. Departure of the trochanter from this line indicates dislocation or fracture or bending of the femoral neck of so much displacement, depending on the amount of this departure. This is an accepted measurement for record.

The vertebra prominens, the spinous processes and the gluteal notch in the normal prone individual constitute a straight line parallel to our base line. Departures laterally to one or the other or both sides constitute a lateral curvature, and backward or forward, an antero-posterior curvature, and must be measured as must be rotations or twists in the spine in the cervical, dorsal or lumbar regions.

Comparative Measurement of Length of Limbs.

After accurately marking the landmarks needed with ink or skin pencil, it is quite easy to measure the lengths desired. It is better not to press the scale of the tape measure on the skin, as the latter is likely to slip, but simply place the scale lightly on the parts and make the reading.

Major Robert D. Maddox, M.C., U. S. Army, suggested that the tape be stretched tight beyond the two points, with the figure 10 at the first point and the number noted at the other fixed point, when the reading could be recorded less 10. This would obviate error from undue or unequal stretching of the tape or slipping of the skin.

Comparative Measurement of Circumference of Limbs.

It can easily be appreciated that owing to the conical shape of limbs, circumferential measurements must vary considerably, if made at different levels; it is essential, therefore, that identical points be chosen on the two limbs for comparison, and these points should be marked with ink or skin pencil at a measured distance below a fixed bone landmark. Thus in the thighs the points chosen should be a given number of inches or centimeters below the anterior superior spines; in the calves, below the tibial tuberosities; in the arms, below the acromions; and in the forearms, below the olecranons. Major Maddox also suggested that in order to get even tension on the tape that the free end be held in one hand, then the part be encircled and the tape case be allowed to fall vertically as a plumb bob. The number 10 is used as the first point, and where the tape passes the 10 after encircling, is read and recorded less 10 (Fig. 90).

Measurement of Angles of Position or Range of Motion in Joints.

The desire to record observations on charts has led in private practice and hospitals, where a sincere effort has been made to keep accurate progress charts, to an endless number of complicated and expensive appliances. Many records were inaccurate, owing to the necessity of application to the patient when the latter is in what might be termed an unstable position, or one in which from time to time, or one may even say from one minute to the next, variations in readings might be observed with proportionate errors. It is therefore essential to accuracy that the positions described above be insisted on, and all measurements of angles be made with relation to the base line or one of its parallel lines on the horizontal table.

It is further important that all readings of the position of extremities or their components be made from a zero position, i.e., neither flexed nor extended, rotated in nor out, pronated or supinated, etc. It is necessary for this basis to be agreed on in comparing results in different clinics. For example, it is manifestly confusing for an author to speak of flexion of the elbow of 70°, when he means 110°, that is, starting from zero or full extension. Similarly semipronation should be pronation of 90°, or supination of 90°.

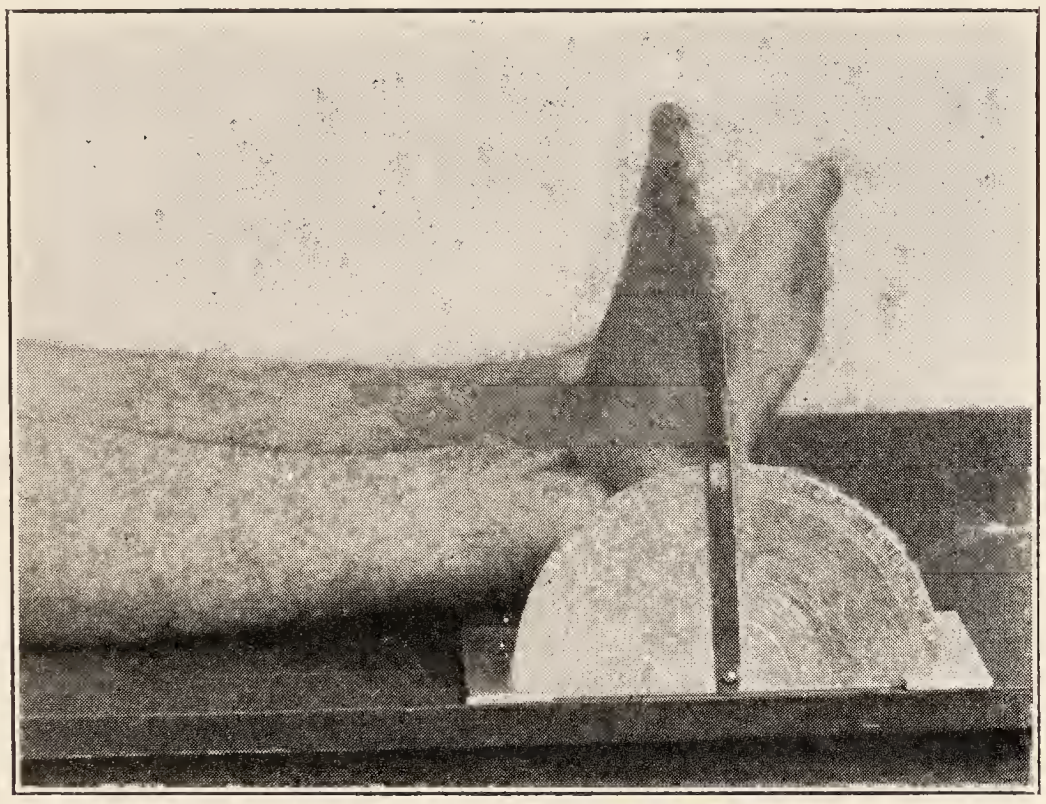


FIG. 95.—Method of recording dorsal flexion at the ankle joint.

It is therefore patent, the author believes, that the method herewith introduced is accurate to all intents and purposes, sound, practical and simple, and may be applied to all the joints with but slight, if any, different findings, if obtained by different observers. This we have proved to our satisfaction by testing the findings of several assistants seriatim and comparing the very negligible error.

Figure 89 shows the recording of adduction at the hip joint, and Fig. 95, recording dorsal flexion at the ankle joint.

CHAPTER XIII

THE PATHOGENESIS OF DEFORMITY

Wolff's Law and Its Corollaries.

In order to understand the technique of orthopaedic surgery in the frequent "over-correction" of deformities, it is necessary to know the pathological changes or physiological transformation that occurs in bone.

If one attempt to analyze the aetiology of the various deformities seen, one will find that they may be classed as those that are congenital in origin, those that are due to trauma, osseous, periosteal or articular disease, post-paralytic contracture, atrophy or weakness, those resulting from habit or burns, and finally those in which faulty nutrition or attitude are to blame.

If one looks further back for the aetiology of acquired deformity one finds two theories; one, the older, known as the Volkmann-Hueter or "pressure-atrophy theory," and the other, the theory of Julius Wolff, of Berlin, known as the "functional transformation of bone" or "the functional pathogenesis of deformity."

Both theories possess points which claim acceptance, but on the whole that of Wolff, though but little emphasized or even mentioned in many treatises on orthopaedic surgery, deserves the wider scientific recognition.

The Volkmann-Hueter theory claims that "consequent upon muscular weakness that faulty attitude is assumed, in consequence of which one side of a joint (or of the trunk) is subjected to greater pressure than is normal and the opposite side sustains less pressure than is normal. Assuming that during growth the normal development of the joint depends upon the maintenance of normal conditions of intra-articular pressure, it was explained that the increased pressure on the concave side interfered with the normal growth of the bone, or even caused atrophy of the bony tissue already formed, while on the convex side the subnormal pressure permitted an over-growth of bone." For example, if this is applied to knock-knee, a manifestation of rickets, one is naturally led to believe that the internal condyle of the femur shows an over-growth and the external an atrophy, but Mikulicz, Macewen, Blanchard, and others, have shown that these changes in the articular surfaces and the epiphyses are not constantly present in knock-knee, but that the principle deformity exists in the diaphyses or shafts of the femur and tibia, which most authors, even today continue to overlook and still describe the pathogenesis of this affection in conformity with the Volkmann-Heuter theory.

The followers of this theory applied the same reasoning to the changes produced in the vertebral bodies in lateral curvature of the spine, in which the shape is changed from a quadrilateral to a wedge shape by the "superincum-

bent weight," producing pressure atrophy on the concave side of the spinal curve and hypertrophy on the convex.

This reasoning, although natural, and at first sight reasonable, is not substantiated by anatomical, pathological and mathematical demonstration (the last named, however, partially) as will be seen from Wolff's researches and able exposition of the subject.

Wolff's Law, to quote Freiberg is as follows:

"Every change in the form and function of the bones, or of their function alone, is followed by certain definite changes in their internal architecture and equally definite secondary alterations of their external conformation, in accordance with mathematical laws."

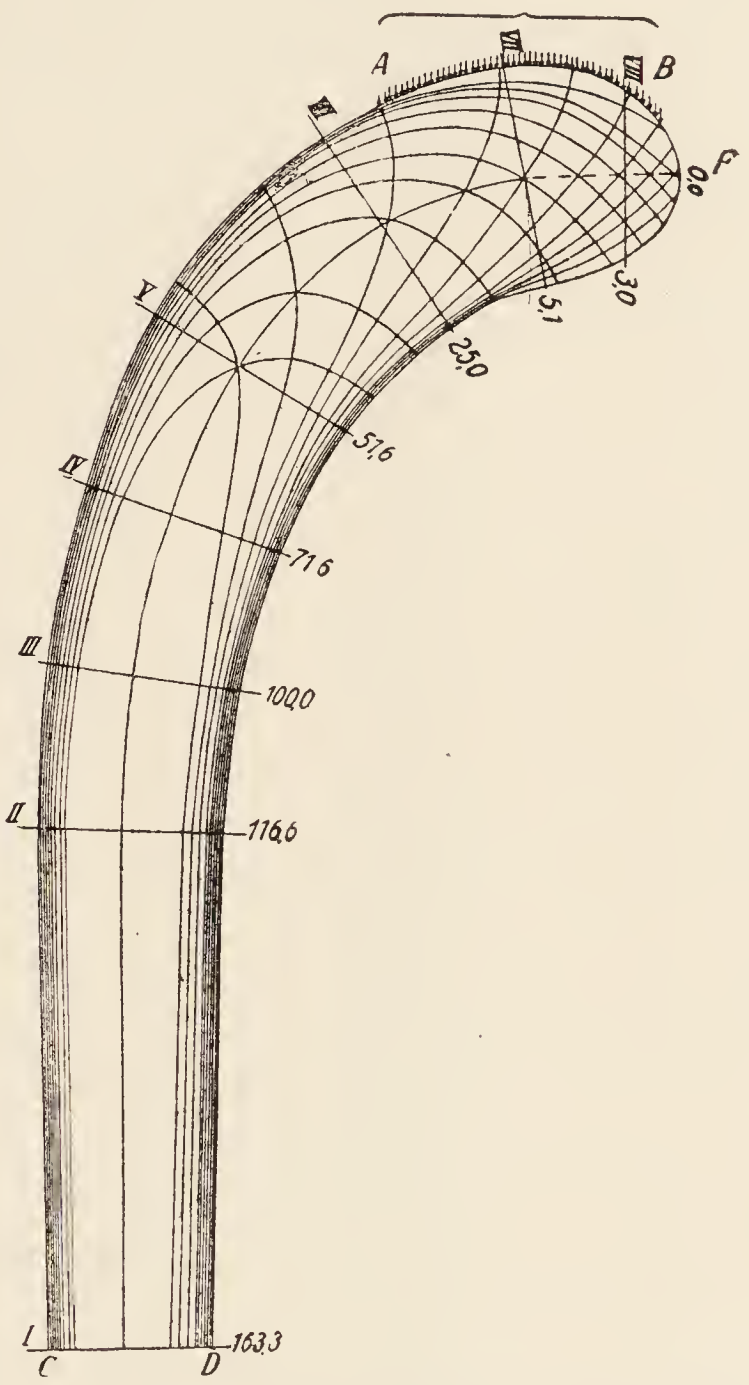


FIG. 96.—Cullman's drawing of Fairbairn crane. (*Young after Hoffa.*)

Wolff formulated his law after painstaking study of the various bones of the body under normal and abnormal conditions, each as a whole or in sections, comparing the cortex and the spongy portion with the functional demands on each, and concluded that the cortical layer was simply a condensation of the spongiosa to meet the demands placed upon it. He attached great importance to the resemblance between the trabecular arrangement in a frontal section of the femur and Cullman's mathematical drawing of a Fairbairn crane, first insisted upon by Van Meyer, in which the trajectories necessary to support a load of 30 kg., approximately the weight of an adult, gave a picture practically identical with the internal arrangement of the trabeculae and lamellae in the human femur deprived of its trochanters. The consolidation of the trajectories on the surface would constitute the cortex as compared with the bone (Fig. 96).

Of course such a calculated mathematical drawing, to have a perfect and absolute similarity to the femur, would of necessity have to include not only the demands to be put upon it in the upright position, but in every other possible position which it might assume, and the various pressures, stresses and shearing strains to which it must be subjected by the muscles.

Such a drawing must show what part the trochanters play as their trabeculae are found continuous with those of the shaft and neck, and their portion in functional burden bearing is no small one, and the drawing must be based on a standard quality of bone, when the "factor of safety" enters into the considera-

tion, as an engineer would calculate the quality of the steel in making the specifications for any structure.

Thus it will be seen that such a calculation to produce a mathematical drawing by graphic statics of the osseous structure would involve the greatest amount

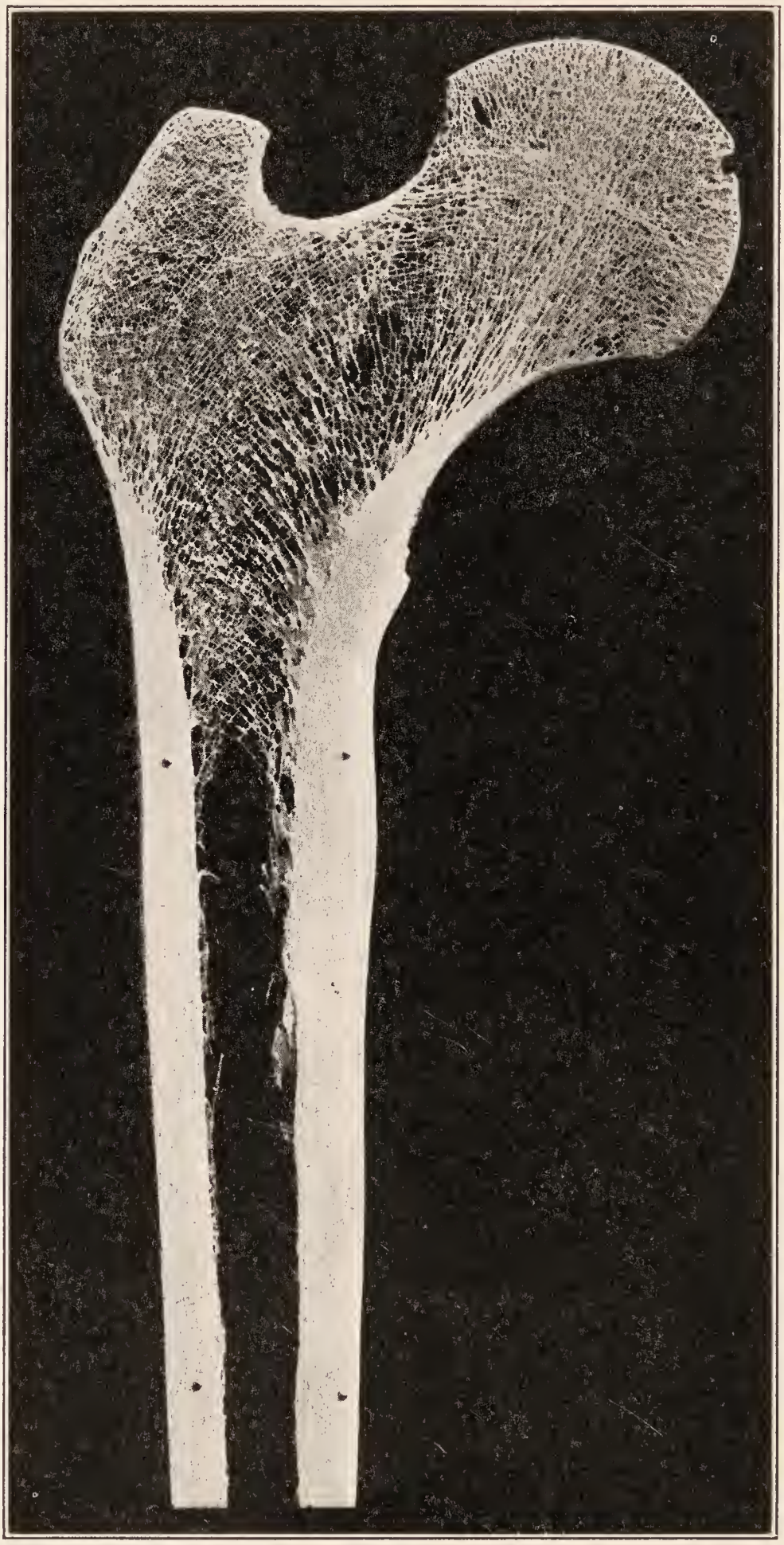


FIG. 97.—Section of upper part of femur. (*Army Medical Museum.*)

of intelligence, knowledge and time and even then would be well-nigh impossible. Nevertheless, the resemblance of Cullman's Fairbairn crane may be regarded as very suggestive and remarkable (Fig. 97).

Working from this, Wolff found that the external form and internal architecture was dependent on the function demanded of the bone and that the external contour and internal architecture always correspond exactly, the former representing mathematically the last curve uniting the various trajectories (lamellae) which make up the internal structure (spongiosa). The compact substance is to be regarded simply as a condensation of the spongiosa. This covers his first corollary that "external shape and internal architecture are dependent on function solely."

From the theory of the "functional shape" it is an easy step to that of the "functional pathogenesis of deformity," his second corollary. If the internal structure and external contour correspond exactly to their demands and if they represent an adaptation to normal function only, then an alteration in the static demands made upon the bones must be followed by the proper transformation in structure, both internal and external, and as the result of these we have the gradual deformity in the "narrower sense," as distinguished from sudden deformity caused by trauma, bone disease, etc., which Wolff speaks of as deformity in the "broader sense."

Thus deformity is to be regarded as a physiological adaptation of the structure to pathological static requirements, therefore, to "pathological functions." Or we could express it as the second corollary that "pathological function produces a physiological bone transformation to meet new static demands."

The great value of Wolff's research is borne out conclusively by anatomical and pathological findings, and the author has deemed it of sufficient importance to go into the subject thus briefly to correct in the minds of his readers preconceived ideas of the older theory of atrophy and hypertrophy in bone according to the Volkmann-Heuter theory (Fig. 98).

Viewing the example cited of knock-knees from Wolff's standpoint, it will be found on section that instead of an atrophy of the external condyle there has been a bone transformation and condensation or osteosclerosis and the internal condyle has not hypertrophied, but undergone an osteoporosis, as the greater strength and weight-bearing in such a case falls on the outer side of the bone. In fact, the cortex above and below the knee will be found thicker on the outer side, to withstand greater strain, than the inner, whereas we know that in the normal bones the cortex is approximately equal on the external and medial sides in a transverse section (Fig. 99).

One so often hears explanations advanced, chiefly by parents, as to why a child is bandy-legged, on the ground that the child is so heavy; one is therefore apt to fall into the error that the superincumbent weight is entirely responsible for the deformity and not the physiological bone transformation to meet faulty or pathological static habits.

Wolff's law is most important of application in the treatment of various orthopaedic affections and especially in the post-operative treatment of them, to allow sufficient time to elapse for this bone transformation in the direction of normal or a reversal of the pathological transformation, which has resulted in the deformity. Thus, for example, many surgeons unfamiliar with orthopaedic measures are surprised to find a club-foot that has been operated on by division of the contracted tendons relapse, when the foot had not been held by a suitable



FIG. 98.—X-ray of knock-knee. Attention is called to the thickened cortex on the concave side of bones.

apparatus, not only to prevent a re-contraction of the soft parts, but also to *permit of bone adaptation* (i.e., functional transformation) to the changed condition.

This law also helps us to understand why it is important in certain conditions, such as knock-knee and bow-legs, to *over-correct* the deformity in treatment, so that, what we may speak of as an osseous balance, may be obtained. Thus in



FIG. 99.—Bowed femora cross-section showing thickened cortex on the concave side of the bones. (*Young.*)

lateral curvature of the spine, if it were possible to hold the trunk for a sufficiently long period twisted in a direction diametrically opposed to that of the deformity, it might be reasonable to suppose that the resultant means of the two curves would approximate the normal. This will be dwelt upon more at length under scoliosis.

The application of Wolff's law will be referred to from time to time in considering the other different diseases.

PART II

SPINAL AFFECTIONS

CHAPTER XIV

TUBERCULAR LESIONS OF THE SPINE

Pott's Disease.

Pott's disease is a pathological process of tubercular origin which attacks the bodies of one or more adjacent vertebrae.

Synonyms.—Hump-back, hunch-back, caries of the spine; tuberculous osteitis of the vertebrae; angular curvature; antero-posterior spinal curvature; spinal curvature; spondylitis and kyphosis. Of these, by far the most preferable are tuberculous osteitis of the vertebrae and kyphosis, which indicate the exact nature of the trouble; kyphosis meaning a backward curvature. Lordosis means a spinal curvature forward and scoliosis means a lateral spinal curvature.

Historical Notes.

This disease was mentioned as far back as B.C. 783 by Galen and Hippocrates in their writings, and they speak of it as "tubercle within and without the lungs." Ambroise Paré wrote of it and used a brass cuirass to treat it in 1579. Sir Percival Pott, of London, in 1779 gave first an accurate description of the gross lesions of the disease in his work, entitled "Remarks on That Kind of Palsy Affecting the Lower Limbs in Curvature of the Spine," therefore, since his time, it has borne his name.

The disease is not limited to the Anglo-Saxon, European, African or Asiatic races, but it existed in the prehistoric American, as is shown by the specimen of an Indian skeleton in the Peabody Museum at Cambridge, Massachusetts.

Pathology.

A small spot of hyperaemia of gray or grayish red granulations is first seen usually in the anterior spongy portion of the bodies of the vertebrae due to the irritation of the bacillus tuberculosis finding a favorable seat for growth in a point of lowered vitality; these granulomatous areas are found to contain characteristic gray or yellow tubercles, which are composed of one or more giant cells have several nuclei and around them massed epitheloid cells, which in turn are surrounded by lymphoid cells. Scattered through this tubercle may be seen, in properly stained preparations, the bacillus of tuberculosis of Koch, either in the giant cells or between them and the lymphoid cells usually. The infection in the majority of cases comes to the bones by way of the blood or possibly lymphatics or by contiguity with other tuberculous tissue (Fig. 100).

This spot becomes larger and redder, the centre becomes opaque and grayish with a zone around it of hyperaemic granulation tissue. The process causing this gray spot is known as "caseation," and is produced possibly by the toxine of the bacilli and the massing together of the cells around the tubercle, and

causing the fatty and cheesy degeneration and necrosis of the central part of the tubercle. Lacunar resorption of the bone always occurs at the seat of the tuberculous granulations and the bone trabeculae become necrotic. If the process is rapid the caseous node thus formed contains these necrotic trabeculae, which in a slow process are absorbed entirely. The hyperaemic zone is the



FIG. 100.—Solitary early tubercle in bone marrow. (*Nichols.*)

area of tubercular granulation tissue and once started increases by peripheral extension. During the later and reparative stages of this process, this area becomes less vascular and is converted into dense fibrous tissue (Fig. 100).

The grayish area grows larger and becomes yellowish in color. As a result we may have, not only as just mentioned, (*a*) caseation simply which is known as "caries sicca," in small nodes which advance slowly, but we may have (*b*)

rapid caseation, which last is known as "caries necrotica" with liquefaction into tuberculous "pus," so-called, to form "cold abscesses," in which swelling is the only inflammatory sign present, redness, heat and pain being absent. As a result of this tuberculous "suppuration," we naturally have abscesses formed of broken down bone tissue and tubercles, which (1) may either point in various directions, discharge and form sinuses; or (2) the masses of caseous material, or the purulent collection may become incapsulated by the surrounding fibrinous and inflammatory tissue, "the so-called granulation tissues," and in turn be absorbed or calcified. (*c*) In either "caries sicca" or "caries necrotica," we may have the process extend by the blending with other granulomatous areas

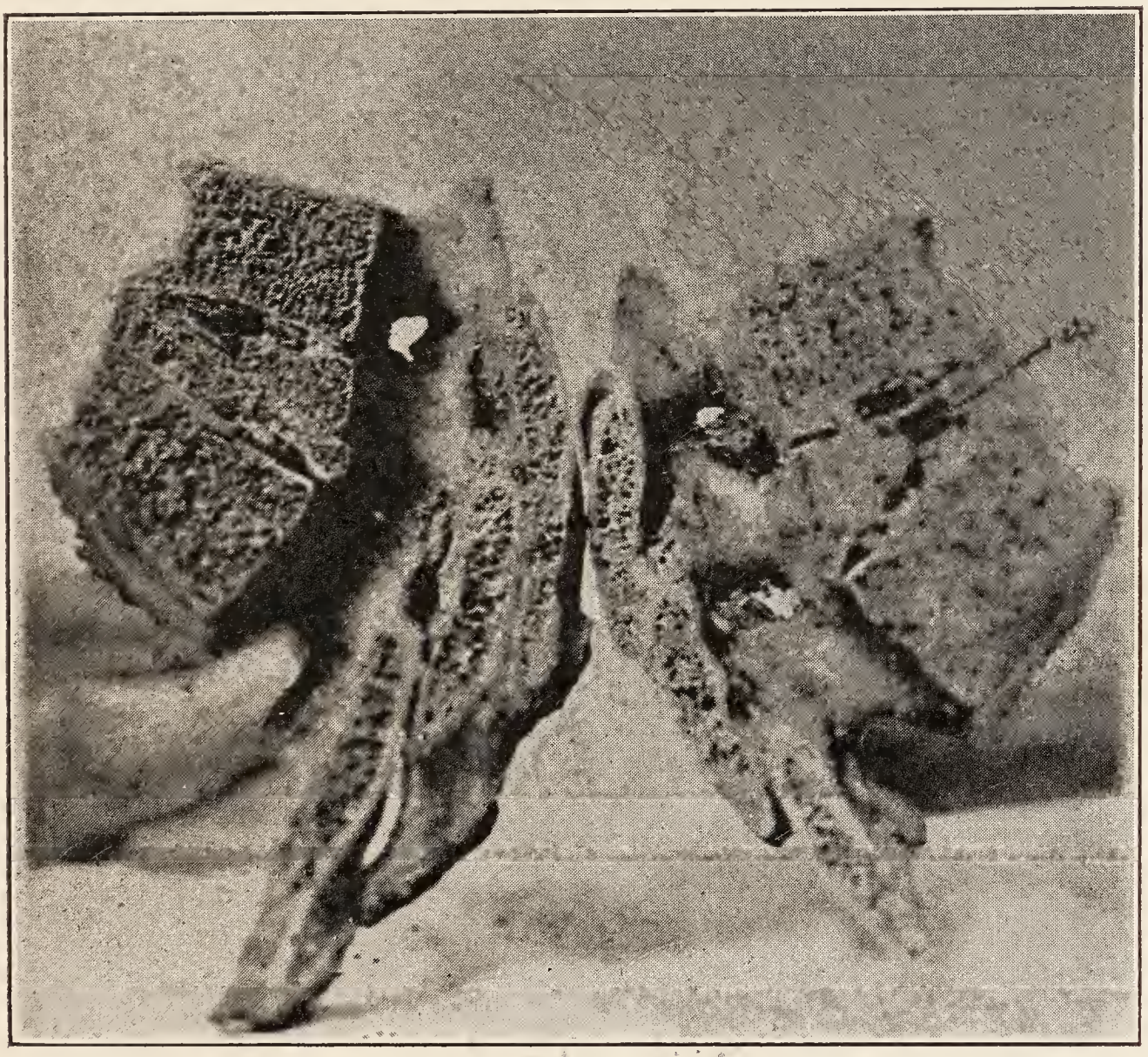


FIG. 101.—Sagittal section of a carious vertebral body, showing abscess cavity at *a*. (*Courtesy of Doctor Holmes Smith.*)

or the actual extension of the original process, from the multiplication of the bacilli and the peripheral bone rarefaction and infection. This explains the putty-like nodes or nodules containing cheesy or calcareous material found in hard bone, and constitute the tubercular bone abscess, hence the name, "tubercular osteitis of the vertebrae." These nodes may be from the size of a pea to that of a hazelnut. The liquefaction of these caseous masses result in a cloaca or cavity, or, as it is sometimes called, a cavernous excavation in the bone. In the osseous detritus one may find gritty remains of necrotic trabeculae or even splinter-like fragments, which when large may deserve the name sequestra but these are not the rule (Figs. 101 and 102).

The transverse, articular and spinous processes are rarely affected as they are covered with hard bone, while the bodies are composed of more spongy bone, which are attacked usually in their anterior portions, softened and disintegrated. As the disease extends to the periphery of one vertebral body, the contiguous surfaces of the adjacent vertebrae and intervertebral discs become involved in the tuberculous process. Some hold that the intervertebral cartilages are first involved; this may be so, but it is certainly not the rule. In any case, where the disease is of any extent, the intervertebral cartilages are



FIG. 102.—Compression Myelitis from tuberculous mass. (*Schulthess.*)

absorbed only at the point of the disease. It is not an articular disease, however. Primary disease at two points not adjacent is rare, though reported (Fig. 105). Superficial osteitis, not causing deformity and absorption of the intervertebral discs, is also rare.

Pus formation may be characteristic of certain cases and is usually indicative either of extensive disease or of an active process or possibly in certain cases to secondary infection with pyogenic cocci. Pus naturally gravitates downward, hence the frequency of psoas abscess in lower spinal caries. An abscess may point into the pharynx as a post-pharyngeal abscess, into the neck, back,

axilla, lungs, abdomen, groin, etc., depending on the situation of the lesion and the line of least resistance. The abscess in the bone we may speak of as primary and that without it as secondary or consecutive. A primary abscess may be absorbed and a secondary abscess also, but the latter usually ruptures either outwards on the surface of the body or into some internal part and so form fistulous tracts or sinuses. At times the luxuriant growth of granulation tissue projects like a mushroom from the mouth of the sinus.

Pachy-meningitis and myelitis may complicate Pott's disease, not, however, from bone pressure, as the lumen of the spinal canal is not often narrowed; for example, deformity may increase and the paralysis may improve, or we may find



FIG. 103.—Microscopic section of cord, showing compression myelitis from tuberculous mass. (*Spiller.*)

paralysis without deformity (Fig. 103). Usually paralysis comes from (1) external tuberculous pachy-meningitis by extension from the diseased bone to the external layer of the dura, which causes a myelitis by pressure at the point of the caries in the bone. The symptoms produced by this lesion are easy to understand, as the pressure is on the antero-lateral aspects of the spinal cord, and therefore the paralysis in the majority of cases will be a paralysis of motion. The myelitis is worse at the point of the meningitis and may destroy the cord there, or be a simple infiltration. Myelitis may be unilateral or bilateral and may extend up or down as an "ascending" or "descending" degeneration, but is usually localized at the area of disease of the bone. Secondarily, by pressure the myelitis causes a paralysis, which depends in extent entirely on the point and degree of the bone lesion. Occasionally paralysis is caused by oedema of the cord from the granulation tissue around the tuberculous area of the bone. In

recovery, there is more or less sclerosis. As a rule the medullary surface of the dura is normal. We may (2) have a bone pressure myelitis from the dislocation



FIG. 104.—Vertebral caries, showing complete bony occlusion of canal. (*Young.*)



FIG. 105.—Case of double Pott's disease (Dorsal and Lumbar).

of one of the vertebrae or separation of a posterior part of a vertebral body into the spinal canal as a sequestrum, but this is extremely rare, (Figs. 104 and 106)

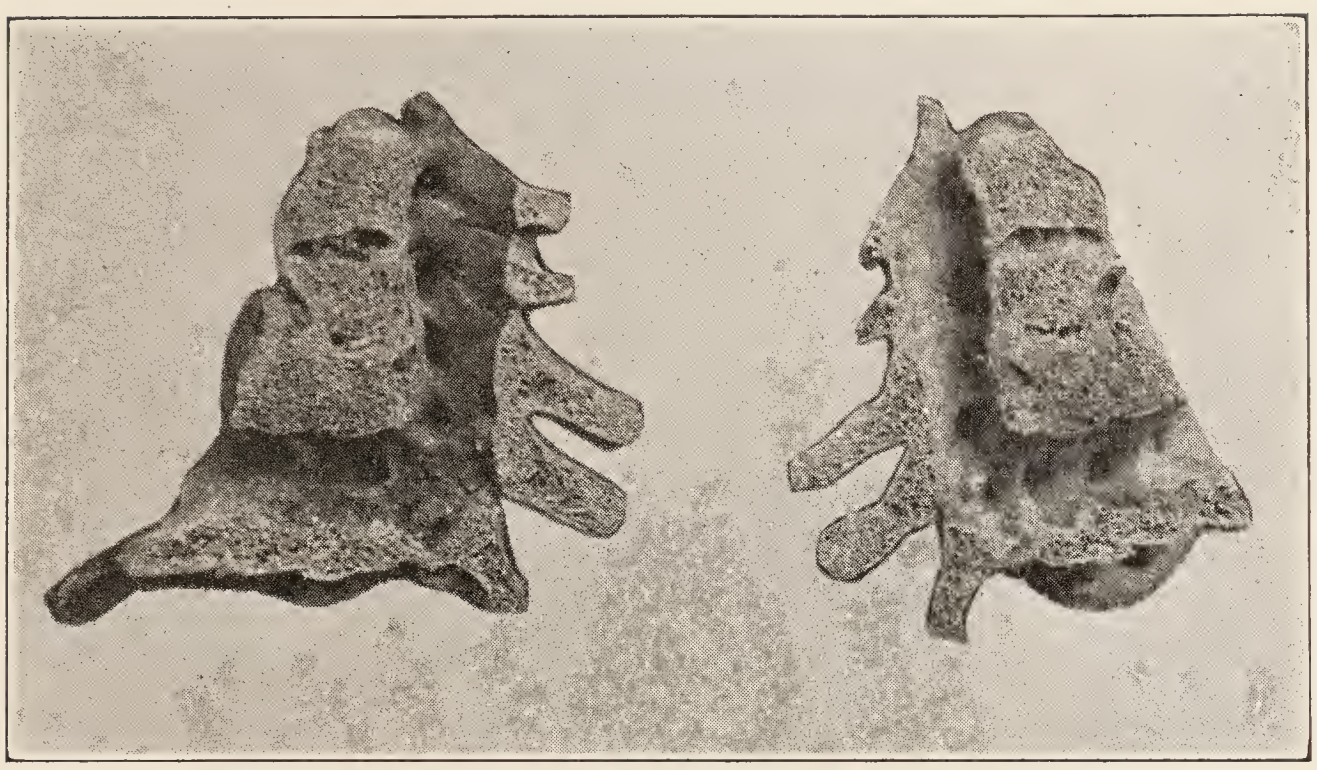


FIG. 106.—Rectangular deformity of Pott's disease. Attention is called to the fact that the spinal canal is not narrowed at the point of flexure. (*Courtesy of Doctor Holmes Smith.*)

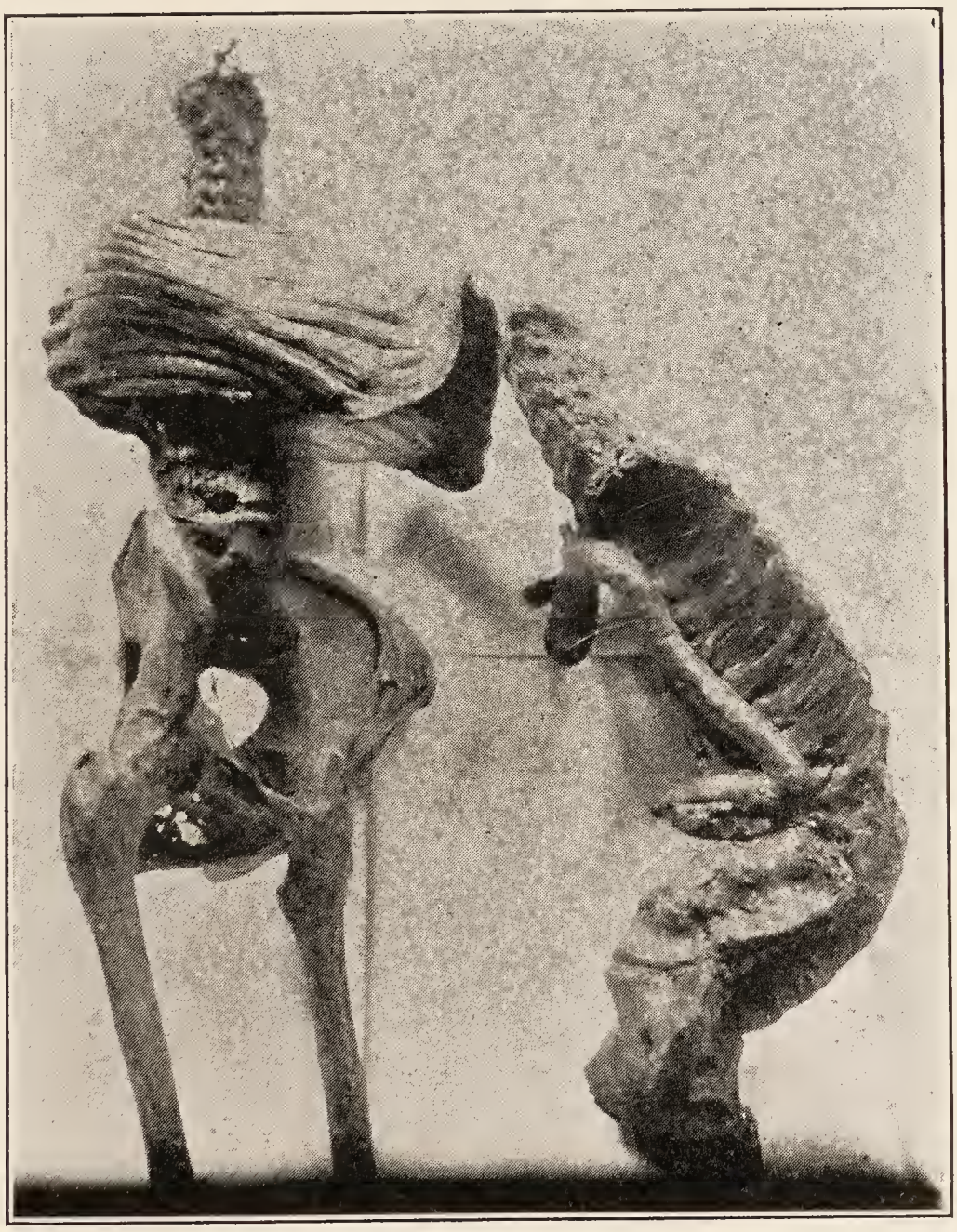


FIG. 107.—Severe case of Pott's disease and flexure of aorta. (*Museum of the University of Maryland.*)

and (3) we may have a myelitis from pressure of an abscess on the cord, due to its bursting into the vertebral canal. The cord is rarely, if ever, involved in the carious process and the postero-lateral aspect of it, is only involved in very severe cases, thus causing sensory as well as motor paralysis (Fig. 104).

Morbid Anatomy.

The morbid anatomy, of course, depends on the region of the spine involved, the extent and the duration of the disease.

In the dorsal region, the shape and capacity of the chest may be markedly and gradually changed in untreated cases on account of the softening of the



FIG. 108.—Attitude in acute cervical disease.

bodies of the diseased vertebrae; the weight of the head and shoulders, pressing down from above, causes a backward projection of the spinous processes (corresponding to the diseased vertebrae) until two sound vertebral bodies resist further extension of the disease and healing, fibrous or bony ankylosis ensue. It is easy to understand from this that if the disease is extensive, that the direction of the ribs will be altered and in severe cases some will project downward, some horizontally and some will sink into the pelvis (Fig. 110). As the spine is shortened from above downward, so is the thorax; compensation in space for the thoracic viscera occurs by the bulging forward of the sternum,

so that the antero-posterior diameter of the chest in a badly hump-backed person is longer than the transverse. In the cervical reigon the neck is shortened and the chin elevated; in the lumbar region the patient is shortwaisted and sway-backed (Figs. 109 and 110).

On account of the intimate relationship which exists between the thoracic and abdominal aorta and the spinal column, when we have an antero-posterior bending of the spine, we may have the same flexion in the aorta, which in a bad case may produce a stenosis. This stenosis may cause hypertrophy of the



FIG. 109.—Types of marked Dorsal disease.

heart and valvular lesions. Cases have been reported of mitral incompetency and degeneration of the cardiac muscle walls (Fig. 107).

We may have phthisis pulmonalis, pleurisy or pericarditis due to extension from the carious bone, or improper and poor expansion of the lungs.

Recovery.

Recovery may occur without deformity at an early stage by incapsulation and cicatrization of the lesion and later by ankylosis of the bodies of the vertebrae with extreme deformity is untreated cases; that is, at best, an exceedingly slow process.

Recovery occurs by means of the granulation tissue, which in healing becomes less vascular and densely fibrous; or a formative osteitis may occur around the

transverse and articular processes, which is the manner of recovery, that is the most unusual under treatment, but is to be desired.

Occurrence.

Sex plays but a minor part, although there are a few more males than females that have this disease.

Age.—Childhood is much the most common time for this disease to develop, the majority of cases which will be seen, begin in children from 5 to 15 years old. The youngest case that has been reported is one at eight weeks and the oldest at 77 years.



FIG. 110.—Extreme deformity in Dorsal disease.

Of all the cases of tubercular bone disease, that we see, about 26 per cent. are spinal.

Aetiology.

Pressure and Position.—The erect attitude increases the superincumbent weight and further irritates any trauma and diseased focus that may exist in the bodies of the spinal vertebrae. It is not surprising, therefore, that this disease has not been reported in quadrupeds and is a penalty that the human race pays for walking erect. The disease has been found at autopsy on monkeys, but without deformity, probably as their habit is more quadripedal than bipedal.

Localization of Disease.

It is needless to say that this tubercular disease may involve the bodies of any of the vertebrae, but it is more common in certain regions than in others; the statistics from autopsies give us approximately the following relative proportions, as to the location of the tubercular focus; in the cervical region, 14 per cent.; in the dorsal region 50 per cent.; in the lumbar region 35 per cent.; and the sacral region 1 per cent. Thus it will be seen that the disease is far more common in the dorsal region than in any of the others, and this has been attributed to the fact that the dorsal region is more exposed to injury, and furthermore in this region the normal spine is convex posteriorly, while in the cervical and lumbar regions it is concave posteriorly. In addition to this we will find that the centre of gravity of the body passes through the cervical region, anterior to the dorsal region and through the lumbar region. As the ribs are attached to the dorsal vertebrae, if any diseased process exists in this region, every respiration that moves the ribs will inflict additional traumatism on the adjacent diseased focus.

Predisposing Causes.

(*a*) Injuries of various kinds, such as falls, blows, and the like, are given in about 50 per cent. of the histories as the predisposing cause of the disease. These produce an area of least resistance for the bacilli to grow upon, as a certain amount of stasis in the circulation exists at the seat of the contusion where the bacilli circulating in the blood or lymphatics find lodgment. This constitutes the infection atrium and after a slight injury it may be months before any symptoms of disease appear while the tubercles are developing and coalescing. Notwithstanding this slow development of the deformity the laity still think hump-back is a "broken back" produced suddenly from an injury.

(*b*) Pressure from one cause or another, notably the superincumbent weight of the head, shoulders, etc., increase the curvature when once started.

(*c*) Lowered vitality, from some of the acute exanthemata of childhood especially whooping cough, is also a cause of lessened resistance to the tuberculous invasion.

Exciting Cause.

The exciting cause is the bacillus tuberculosis, causing caries of the vertebral body or bodies. This bone tuberculosis may be hereditary or acquired. Approximately 75 per cent. of all the cases seen give an inherited family history of one form or another of tuberculosis. This is now thought to be by subsequent infection and not by direct intrauterine transmission from parent to child.

Symptoms.

1. **Onset.**—All symptoms come on very gradually and the insidious onset of this disease is most characteristic.

2. **Muscular Rigidity.**—This a constant and reliable, early and late symptom of practically all tubercular bone diseases, and in the spine, we will find it shown by the attitude, carriage and motions of the patient.

Arbitrarily, we may divide the spine into four regions, in order to analyze these attitudes, etc., should disease attack one of them.

The first region consists of the first three cervical vertebrae. (Whitman includes in this region the occipito-atloid articulation with its motions of rotation, flexion and extension) (Fig. 108).

The second region consists of the fourth, fifth and sixth cervical vertebrae.

The third region extends from the seventh cervical through the tenth dorsal, and the last region extends from the eleventh dorsal through the fifth lumbar.

Now, if we examine the spine, we will find that in the first region, the normal motions of the vertebrae on each other, are those of rotation so that if any reflex stimulus, as seen in the acute stages of Pott's Disease, is given to the muscles,



FIG. 111.—Postures in acute dorsal and lumbar disease.

which regulate the motions in this region, we will find the head held in some position of torticollis or wryneck; therefore, if we have a tubercular focus in this region, the child's head will be markedly rotated; all the muscles that are attached to this region will be rigidly contracted, and the child will endeavor in every possible way to protect the injured part from jar or motion, as well as pressure. It will endeavor to remove the pressure by resting its head in its mother's lap or throwing itself across a table or chair, or by supporting the head with the hands (Fig. 108).

In the second region, we find that the vertebrae, by their shape, so articulate as to enable the head to be moved in flexion and extension, therefore in this

region "the neuromuscular expression" of the disease is that either the head of the child will be flexed forward with the chin resting on the sternum or extended backward with the occiput resting on the spine. The child exerts the same precautions to protect the disabled part from injury, etc., as in cases in which the disease is in the first region (Fig. 108).

In the third region, the shoulders will be very squarely held and lifted up. The child will endeavor to prevent the upper part of the body pressing on the diseased area and will support it by resting the hands on the knees instead of



FIG. 112.—Lumbar disease.

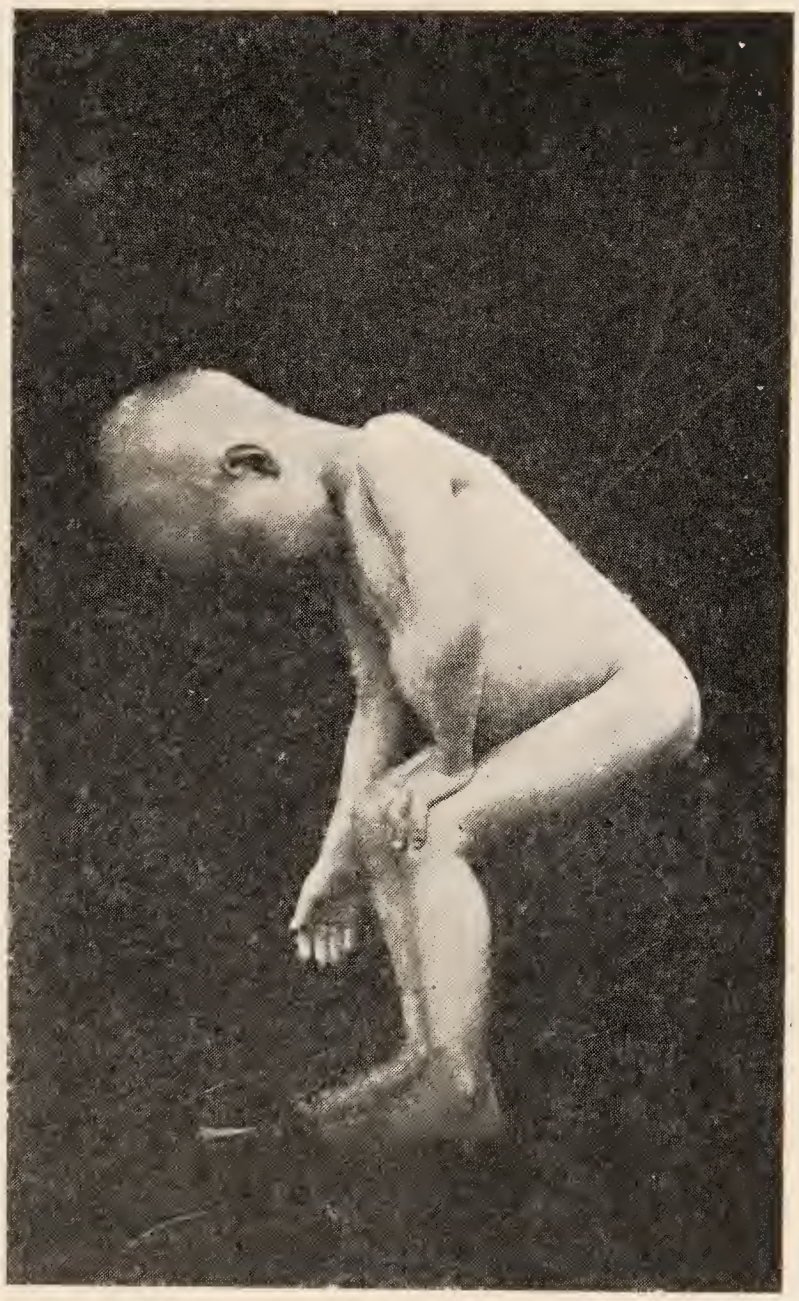


FIG. 113.—Characteristic method of stooping in Pott's disease.

standing erect. If asked to walk, it will do so by catching hold of chairs and tables in passing, to relieve the weakened spine of some of its burden. Every motion is taken with the greatest care to prevent jar and if any object is thrown on the floor and the child is requested to pick it up, it will do so by squatting instead of flexing the body forward, which procedure would jam the bodies of the adjacent well vertebrae against the diseased tender one (Figs. 111 to 113). In the same way, if a child with the disease in this region is put in a sitting posture with the legs extended on the examining table, it will be found that, unlike a normal child, it is unable to touch both feet with both hands at once, as it is unable to flex the spine forward owing to the muscular rigidity, which is nature's method of protecting the diseased area. Also if such a child be placed on his

hands and feet, and the examiner place the palms of his hands under his abdomen and lift him, the spine will be held straight and not bowed as is normal, for the same reason.

In the fourth region, as we have seen on examining the normal vertebrae of the spinal column, the convexity is forward, unlike the third region and at the greatest possible advantage for throwing the weight off of the diseased area, so that instead of the superincumbent weight of the body being anterior or on the diseased bodies of the vertebrae, it can be thrown posterior to them and supported on the articular and transverse processes of the lumbar region; thus, we will find the attitude in this region that of lordosis or swayback, such children having almost a military bearing, but walking and moving with the greatest care. Their stooping attitudes and motions are the same as those seen in the dorsal region. Such are the characteristics of active motions in the acute periods of this disease, especially in flexion of the spine before or after deformity has occurred (Fig. 111).

If such a case be placed face downward on an examining table and then so lifted by both legs at once, so that the sternum and face are still in contact with the table, it will be found in thus extending the spine that the vertebral column does not form an arc, as is normal, but is held straight and stiff by muscular spasm, not as though it were composed of many segments but as if it were one piece (Figs. 122 and 123).

In diseases in the lower dorsal and lumbar spine, we find reflex irritation of the psoas magnus muscle in some cases during the acute stage from its proximity with the diseased bodies, which produces the contraction, causing flexion of the thigh on the body; this is known as "psoas contraction," and if it continues for a long time, so that the muscle and Y-ligament become shortened permanently, it may result in a very difficult deformity to overcome. There may be more or less flexion of the knees in all cases of Pott's Disease, owing to an effort on the part of the sufferer to lessen the shock on the diseased spine and make the step more elastic and as little on the heels as possible.

3. **Pain.**—Pain is a common symptom of Pott's Disease, but this pain is not usually present in the spinal region and is referred to the anterior portion of the body at the peripheral ends of the sensory nerves only when the disease is in the acute stage. This is due to pressure or inflammatory irritation of the nerves as they make their exit through the spinal foramina. In cervical Pott's Disease we will find the pain in the back of the head, or in the front of the neck or shoulders, while in dorsal disease the pain is in the front of the chest or stomach; and in lumbar disease the pain may be felt in the legs or hypogastric region or loins. It may simulate the pain of pharyngitis, pleurisy, pneumonia, peritonitis, cystitis, gastritis, etc. Careful examination of the spine is frequently necessary to make a diagnosis when pain exists without deformity. The pain as a rule is subacute, rarely being acute, except when the disease is at its height. In cervical disease the reflex nerve irritation may give rise to a croupy cough and respiration like that present in laryngeal stenosis.

4. **Night Cries.**—The "night cry" is a symptom which indicates very active disease. It is heard in the early part of the night and is probably due to a relaxation of the muscular spasm and the grinding of the healthy bones against

a diseased one. A child will give a sharp cry and by the time a parent or nurse has reached its side, it will be asleep again, the muscular spasm being re-established. This may be repeated several times. Patients that are old enough to describe their sensations say that the pain occasioned is of a dull, aching character and may persist for a little while. There is no dream with these night cries, as is the case in nightmare. Often the child does not really wake at all, is simply disturbed in its sleep and gives the cry.

5. **Deformity.**—Deformity is present after the disease has advanced and caused more or less destruction of the bodies of the vertebrae. It is easily made out by examining the spinous processes and may be extremely slight, constituting simply a small knuckle, or it may be extensive, including the spinous and transverse processes of several vertebrae with their ribs and produce a large hump. If one examines the spines carefully and notes the seventh cervical vertebrae, the vertebra prominens, it is easy to see that normally there is no such projection in the others, so that even in slight disease, any such deformity is easily made out. This when present constitutes an antero-posterior deformity with the convexity backward. Occasionally we may see a lateral deviation, due to the diseased process being more extensive on one side of a vertebral body than on the other. As the vertebral bodies soften more and more from disease the deformity increases. This lateral deviation, however, does not produce the extensive rotation of the ribs that is seen in true rotary lateral curvature of the spine, due to muscular weakness, faulty positions, and the like.

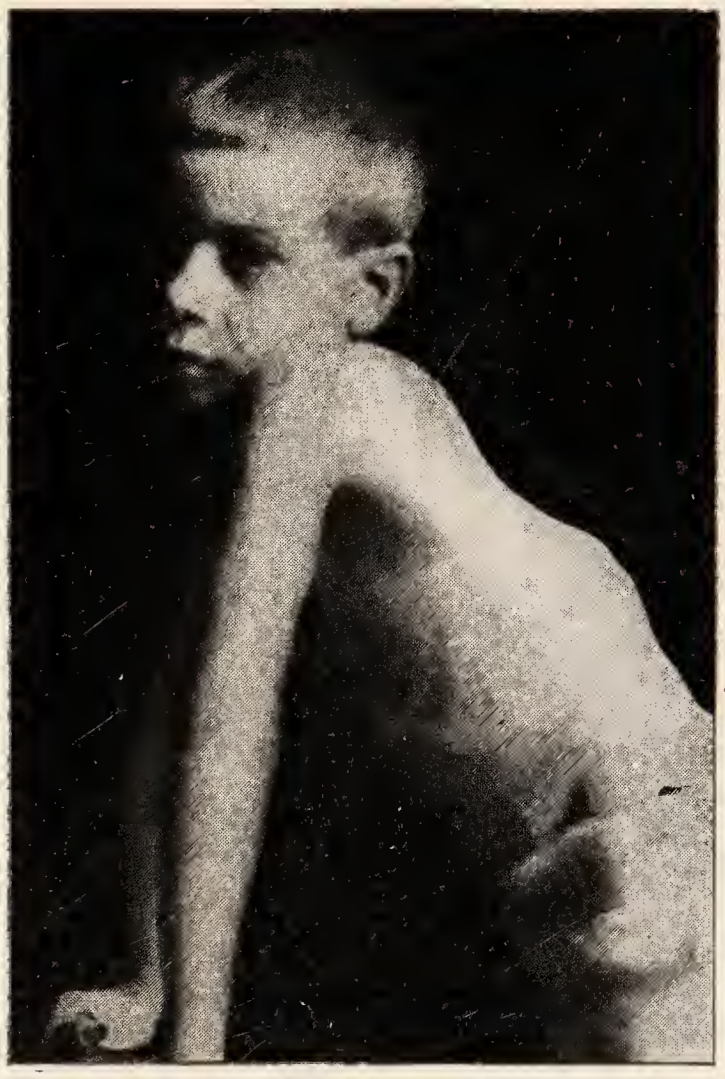


FIG. 114.—Double Pott's disease, dorsal and lumbar.

Secondary compensatory antero-posterior curvatures follow the primary one:

(*a*) In cervical caries we find dorsal incurvation and lumbar excurvation, *a reversal* of the normal physiological curves, and an abnormal flattening of the whole spine in cases of moderate severity. Abnormally short necks are found in severe cases.

(*b*) In dorsal caries we have incurvation above and below the deformity or an *exaggeration* of the normal kyphosis there and the other physiological curves.

(*c*) In lumbar disease, we have incurvation above the gibbosity, lessened dorsal kyphosis with a tendency to dorso-lumbar lordosis.

Short neck and short trunk are characteristic of severe cervical and dorso-lumbar disease, respectively, when much tissue from the vertebral bodies has been destroyed. We usually find restricted growth of the whole body, but the

limbs and head in bad cases seem abnormally long and large, respectively, and the characteristic pinched pained expression of the face in dorsal caries is seen. A double deformity is rare (Figs. 114 and 105).

We may have arrest of the disease with little or no deformity in the cervical region. Pain and chafing under a brace in the dorsal region may precede increasing deformity or renewed activity of the disease.

The chest is usually thrust forward and downward by dorsal disease and compressed laterally giving rise to "pigeon breast," which may be the first symptoms noted as the back is often overlooked. This is explained as an antero-posterior compensatory increase for the loss in the capacity of the chest from above downward. The ribs may be prominent (i.e. protrude beyond) on either side of the sternum and vertebrae, from bending (Figs. 107 and 110).

6. **Grunting Respiration.**—This symptom is almost pathognomonic of acute dorsal Pott's Disease. If low down, we will find more thoracic breathing; if high up, more abdominal. Nature thus tries to prevent the ribs jarring the diseased focus and the muscular spasm holds the ribs articulating with the diseased area as motionless as possible.

7. **Paralysis.**—Paralysis is rarely an early symptom, but may exist without deformity, although this is an exception. (*a*) Motor paralysis is the rule and varies from a slight fatigue or dragging of the feet at the onset, to an inability to hold one self erect or move the lower extremities at all. About 5.6 per cent. of all cases of Pott's Disease have paralysis. (*b*) Sensory paralysis is an indication of very extensive disease (postero-lateral tracts) as was explained under pathology, and is rarely if ever complete. (*c*) The reflexes, viz; the knee jerk and ankle clonus, even before the paralysis is evident, are exaggerated except when the disease is at the lumbar enlargement; exaggerated reflexes may persist for some time after locomotion is possible; muscular spasms may be spontaneous. The muscles become flabby and powerless, and (*d*) rigidity follows only secondary degenerations. (*e*) Paralysis of the sphincters of the rectum and bladder is present towards the end of all bad cases and those of long duration, and involvement of the lumbar enlargement. (*f*) The arms are paralyzed in a very few cases from extension of the pressure myelitis or pachymeningitis and not usually from ascending secondary degeneration of the cord. (*g*) Trophic and electrical changes in the muscles are rare except when the cervical or lumbar enlargements are involved, then we get atrophy greater than that of disuse and the reaction of degeneration. In severe cases, after prolonged suppuration, we may have a condition of asthenia, with psoas contraction, which may cause a patient to be bedridden without true paralysis. The paralysis is more commonly bilateral and is seen more frequently accompanying *cervical* and *upper dorsal disease*, than the other forms. It rarely lasts more than three years and is usually less than one year in duration if properly treated. The average duration is seven months under efficient treatment. Paralysis is rare (5.6 per cent.) under effective treatment, but if present, as a rule yields readily to it. Extreme pain may precede paralysis. Recurrence of paralysis is rare, though as many as three relapses have been reported. Extreme hyperaesthesia is sometimes present with the sensory paralysis, so that even the bedclothing or hand passed over the paretic region will cause intense pain and muscle spasm.

8. **Abscess.**—Secondary abscess may be cervical, dorsal, mediastinal, axillary, lumbar, iliac, psoas, etc., depending on the seat of the original disease. Psoas abscess, however, is the most frequently seen, even in dorsal disease, as the pus burrows down the sheath of the psoas muscle in the ligamentum arcuatum. Why abscesses should appear externally in some cases and not in others, is not clearly understood, but in some cases (*a*) trauma, such as a fall, blow, etc., may be considered responsible for rekindling the process into activity and increasing its severity, (*b*) lowered vitality may be responsible for abscess in some cases, as the organism is unable to resist the inroads of the disease; (*c*)



FIG. 115.—The right-hand child has a left tubercular hip disease with abscess. The left-hand child has Pott's disease with left psoas abscess.

imperfect support is responsible in many cases; (*d*) extremely active disease and great numbers of bacilli in others; (*e*) in lumbar disease where secondary abscess is most frequent is explained by the fact that the entire weight of the upper portion of the body is pressing on the diseased focus (Figs. 115, 116 and 117).

Secondary abscess consists of caseous or calcified masses, necrotic bone trabeculae in sero-purulent fluid and a few scattered bacilli tuberculosis. It is entirely unlike an acute abscess and is painless except at the time when the primary abscess breaks through the bony wall at its origin, and is known in contradistinction to an acute abscess, as a "cold" abscess. If an abscess bursts

into the lung or pleural cavity, it may set up a tuberculous pneumonia, lung abscess or empyema. If into a bronchial tube, it may be coughed up unless extremely large, when it may lead to collapse or apnoea; if into the peritoneum it may cause a tuberculous peritonitis, and into a blood-vessel it may result fatally. If it should burst into the hip joint it may start up tuberculous disease there secondarily. It may burrow through into the femoral or inguinal canals



FIG. 116.—Lumbar abscess.

and simulate herniae; these are rare of course. In a very small percentage of cases of cervical or occipito-atloid disease, we may see post-pharyngeal abscess, which need not be considered fatal, as was thought formerly, for this with proper care can be aspirated or it may dribble away, drop by drop, from a small opening and not with a gush, or it may break or be incised on the side of the neck and not lead to strangulation. The lower down in the vertebral column a spinal caries occurs, the more liable is it to be complicated with abscess. As a

rule, an unopened abscess causes little or no general disturbance and is best left alone unless it reaches such a size as to cause interference with some of the important bodily functions, as perfect drainage and erasion is necessarily impossible. Our main reliance should be in perfect support rather than hasty incision, where perfect drainage is impossible. In certain instances it would seem where the skin is unbroken but thin over a cold abscess, that a hectic condition and *secondary infection* with cocci has occurred. Blood examination gives a *high leucocytosis only* in secondarily infected tuberculous abscesses. Secondary infection may occur so readily in an open tuberculous abscess or sinus and so often is the cause of the fatal termination of these cases, it cannot be too zealously guarded against. The aureus, albus, streptococcus or colon bacilli will usually be found as the complicating organism (Figs. 118, 119 and 120).

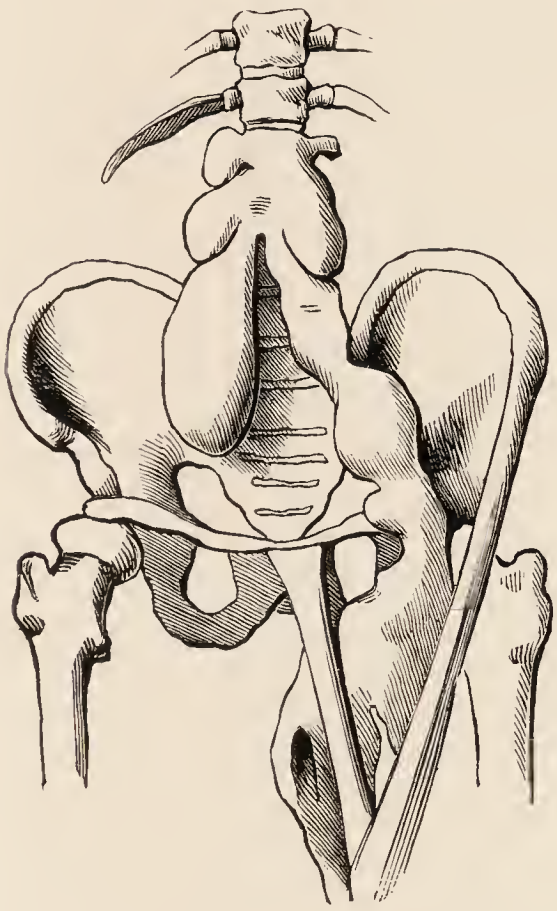


FIG. 117.—Lumbar and psoas abscess. (*Hoffa.*)



FIG. 118.—Psoas abscess. (*Hoffa.*)

9. **General Condition.**—The general condition of a patient is more affected from severe Pott's Disease than from any other bone disease. If extensive, it causes retarded growth, often the head and limbs may seem abnormally large and long, respectively, as their growth is not affected by the diseased process as the spine is. The sternum may be very prominent in cases where the deformity is large from collapse of the chest from above down. In some cases, the ribs and cartilages on either side of the sternum may be more prominent than normal and cause the sternum to appear depressed (Fig. 110).

Children with this trouble are usually fretful, spoiled and capricious; they are often precocious, but delicate and liable to cold, slight pneumonia, heart trouble and attacks of supposed stomach ache, the spinal pain being referred to the peripheral distribution of the sensory nerves.

Tubercular meningitis and general miliary tuberculosis is rarer in this disease than in hip disease. There is in the onset of the disease, little or no

general disturbance, but as the disease advances, we will find the appetite, nutrition, sleep and other normal functions of the body seriously impaired.

In those cases which have sinuses (often secondarily infected) discharging for a long period of time, months or even years, a cachexia ensues, the patient

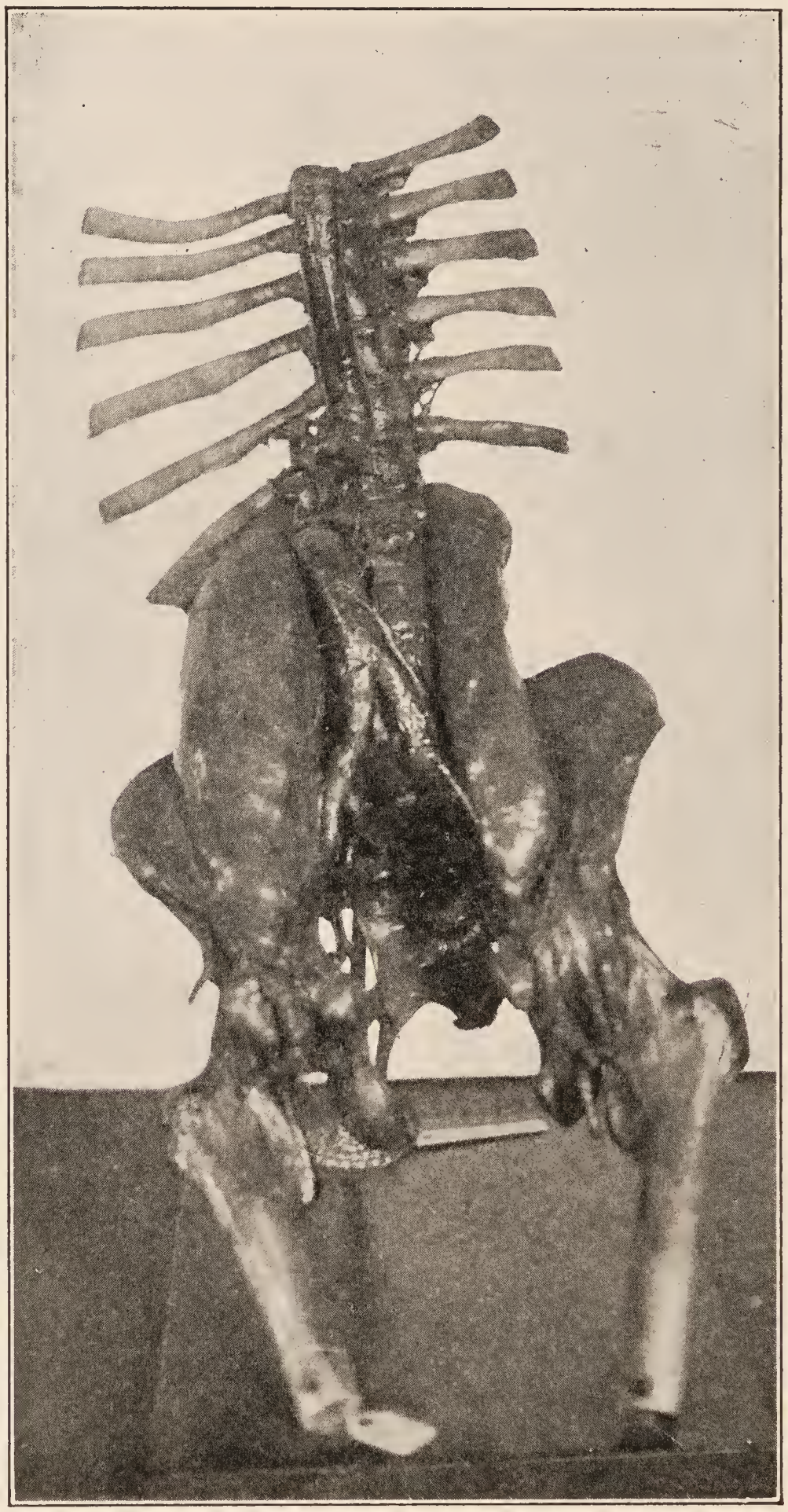


FIG. 119.—Double psoas abscess. (*Young.*)

has a waxy color, amyloid changes may occur in the viscera, oedema and dropsy ensue, and a secondary anaemia be noted in the red and white blood cells (Fig. 121).

10. **Temperature.**—In all cases where the disease has established a footing, there is more or less elevation of temperature. This rarely if ever amounts to

a hyper-pyrexia, and we may say as a rule that the temperature of tubercular bone disease varies from a subnormal morning temperature to 99½° to 101°F. in the afternoon. When, however, a secondary abscess occurs with a discharging sinus and this sinus and abscess cavity become secondarily infected with pyogenic bacteria, "hectic fever" sets in, with a low morning temperature and high evening temperature (102° to 105°F.) with chilly sensations, sweats and the characteristic "hectic flush" in the cheeks present.



FIG. 120.—Pott's disease with abscess complicating femoral hernia.

Diagnosis.

The diagnosis is made by considering the symptoms mentioned, such as: (1) Stiffness of the neck or back with marked muscular spasm; peculiar attitude and gait; (2) night cries; (3) seat and localization of the pain and the character of the nervous symptoms; (4) prominence and irregularity in the line of the spinous processes; (5) psoas contraction in dorso-lumbar disease and grunting

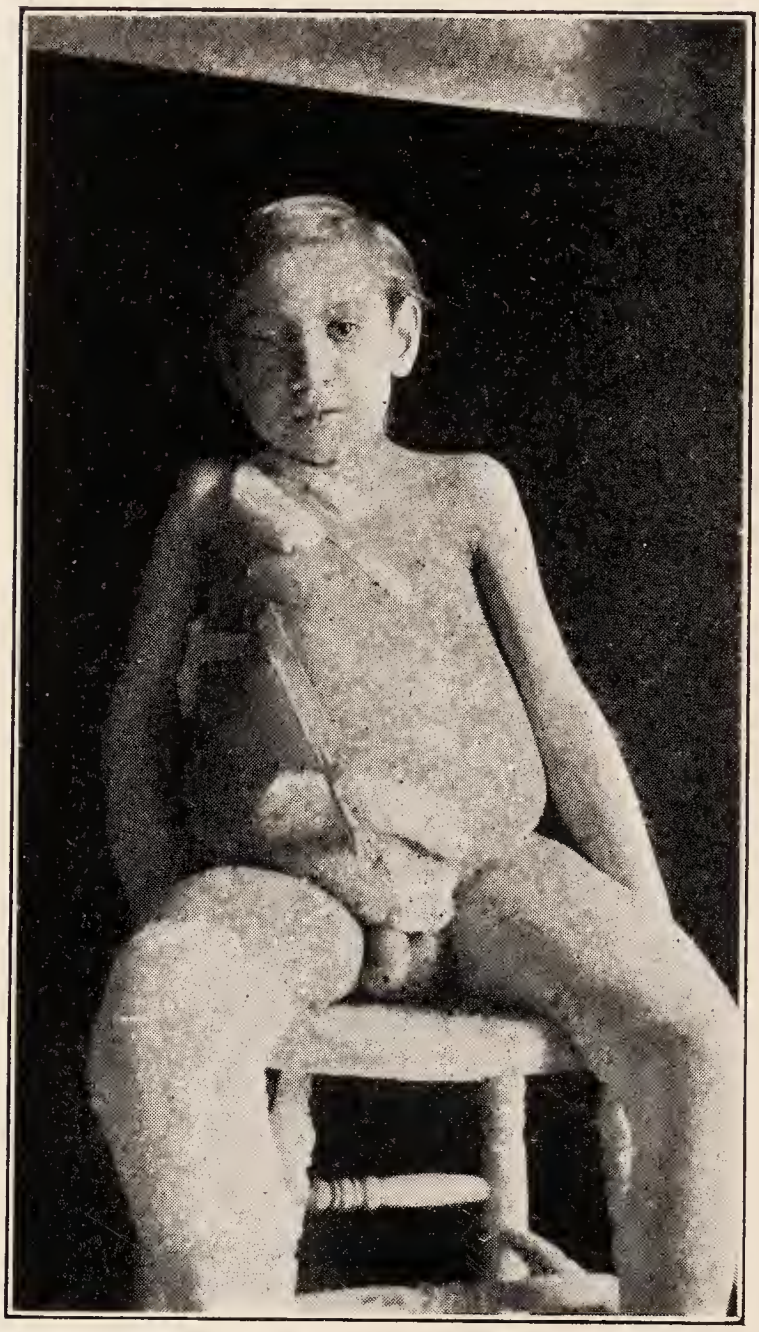


FIG. 121.—Amyloid disease of the viscera complicating multiple tubercular bone lesions with secondary infections. Dropsy.

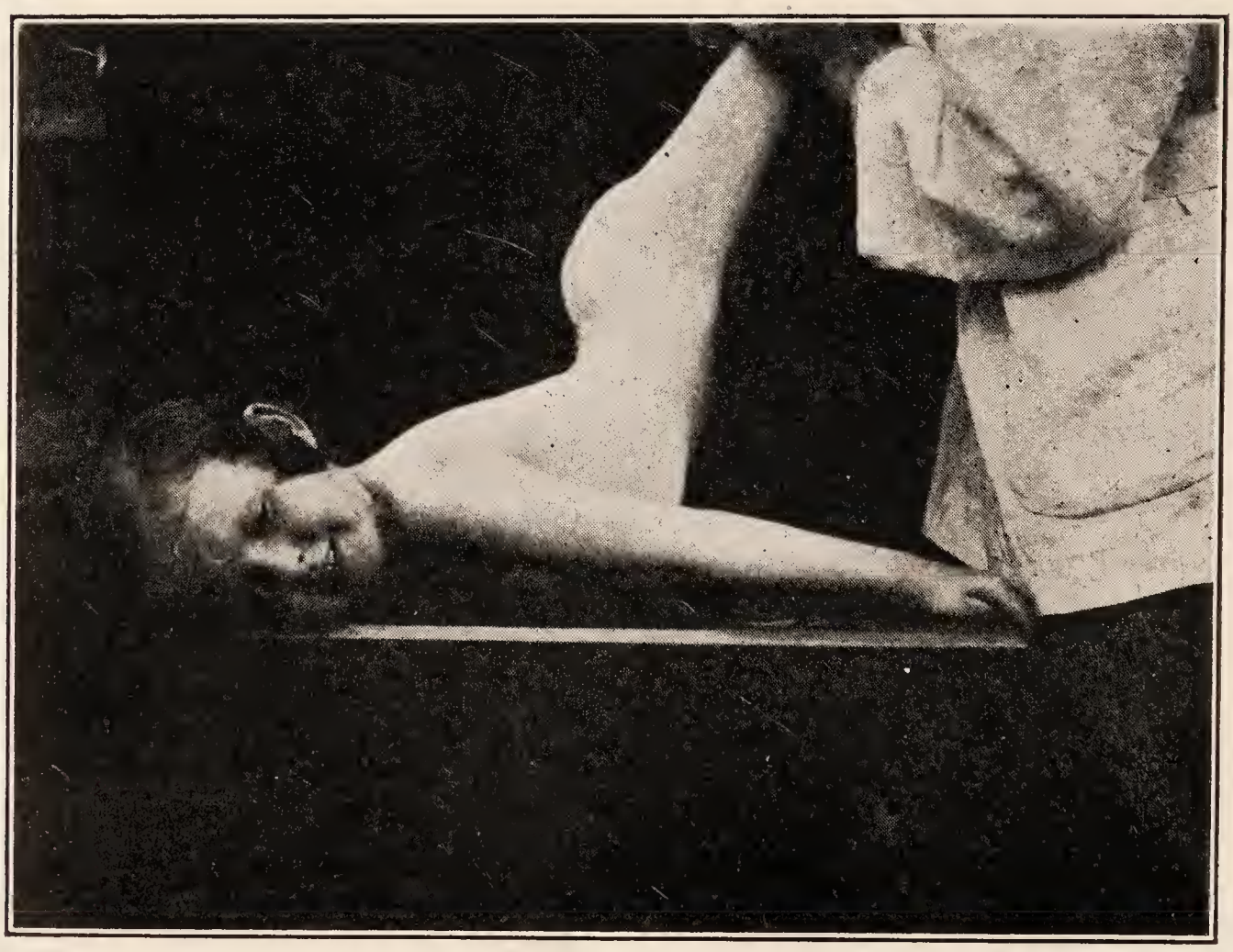


FIG. 122.—A normal flexible spine.

respiration in acute dorsal disease; (6) abscess; (7) temperature; together with (8) family history; (9) the skiagraph; (10) the blood count; (11) the insidious onset; (12) the tuberculin test.



FIG. 123.—A rigid spine in Pott's disease.

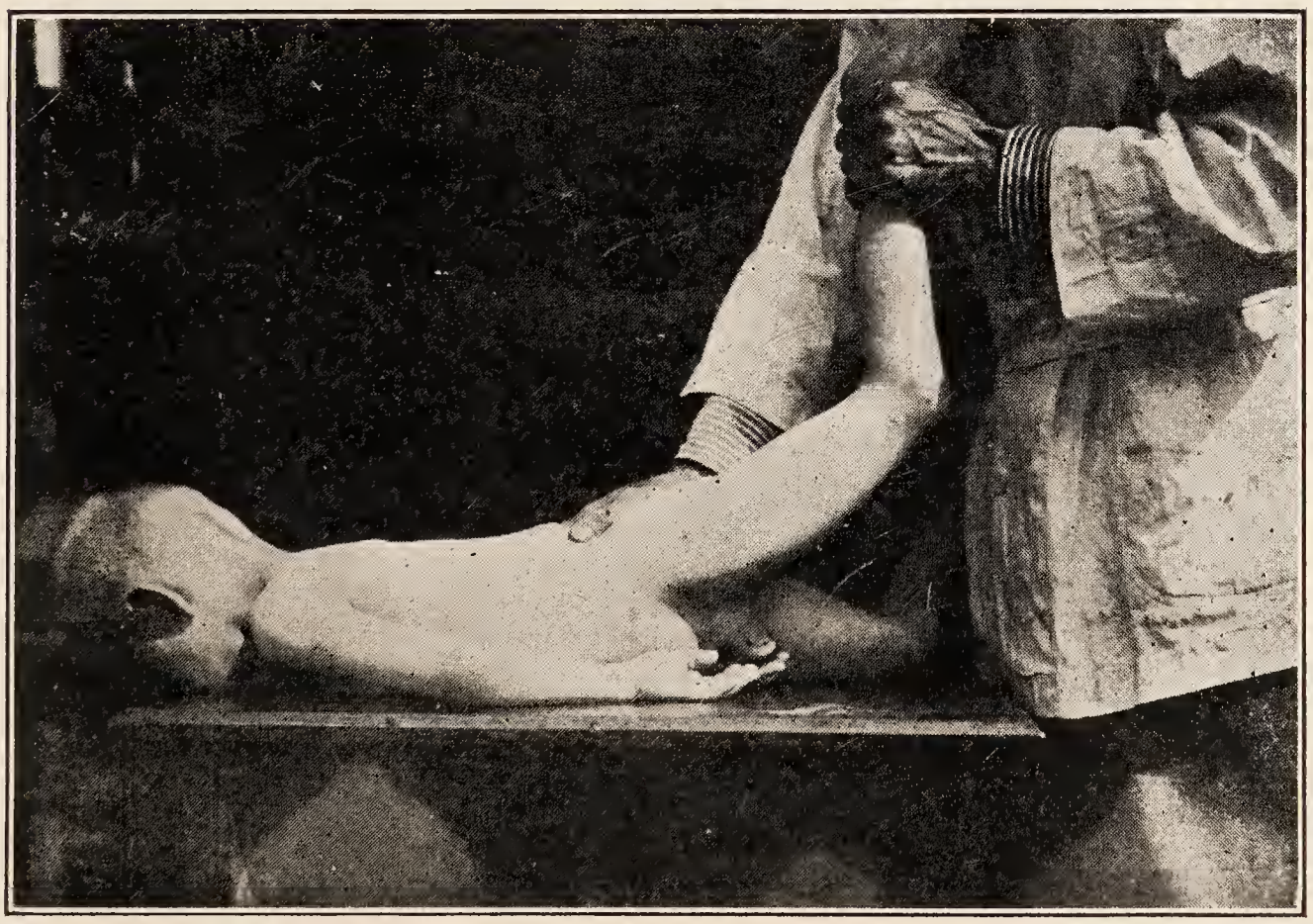


FIG. 124.—A test for psoas contraction.

Stiffness of the spinal muscles is easily made manifest by requesting the child to stoop and pick anything up, which it will do without bending the back;

(Fig. 115) the same may be said of its efforts to touch its toes when sitting. When lying on its face, if the examiner attempts to raise the child from the examining table by its feet, instead of the back arching anteriorly as it does normally into a perfect bow, it will be held flat (Figs. 122 and 123). There is



FIG. 125.—Whitman's test for psoas contraction.

also no lateral flexibility. We can demonstrate the spasm of the erector spinae group by raising the child when his hands and feet are touching the floor, by placing one's hands under the abdomen when the spine will be held flat and rigid (Whitman's sign). Psoas contraction is easily diagnosticated by having the child lie on its face and flexing its legs at a right angle with its thighs, so

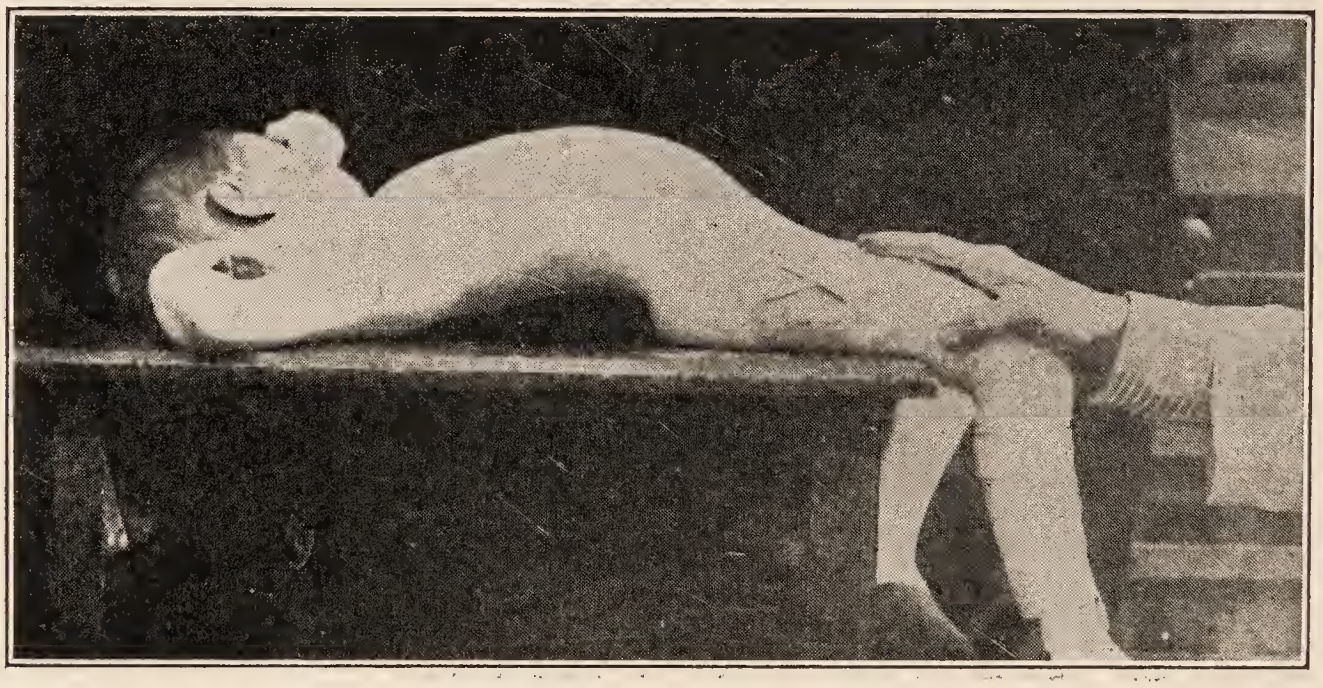


FIG. 126.—Whitman's test for psoas contraction. Same patient seen in Fig. 125. (Note arched lumbar spine as the flexed leg from the contracted psoas muscle is pulled down to the table.)

that resistance will be detected in one leg when the examiner extends first one leg and then the other, by raising them alternately from the examining table, when the hand is held over the sacrum (Fig. 124). Psoas spasm can also be shown by allowing the child to sit on the edge of a table and let the legs hang

down, the normal leg will hang lower than the affected one (Whitman). Of course if both legs are rigidly flexed on the abdomen one cannot get such a patient to lie flat on the abdomen in making the usual test (Figs. 125 and 126). Psoas spasm is a valuable sign in commencing lower dorsal and lumbar disease, as well as beginning abscess and becomes more pronounced as the disease becomes more extensive. The iliac fossae should be carefully palpated and percussed for abscess as a matter of routine in all cases of lower dorsal and lumbar Pott's Disease and percussion and auscultation should be employed over the

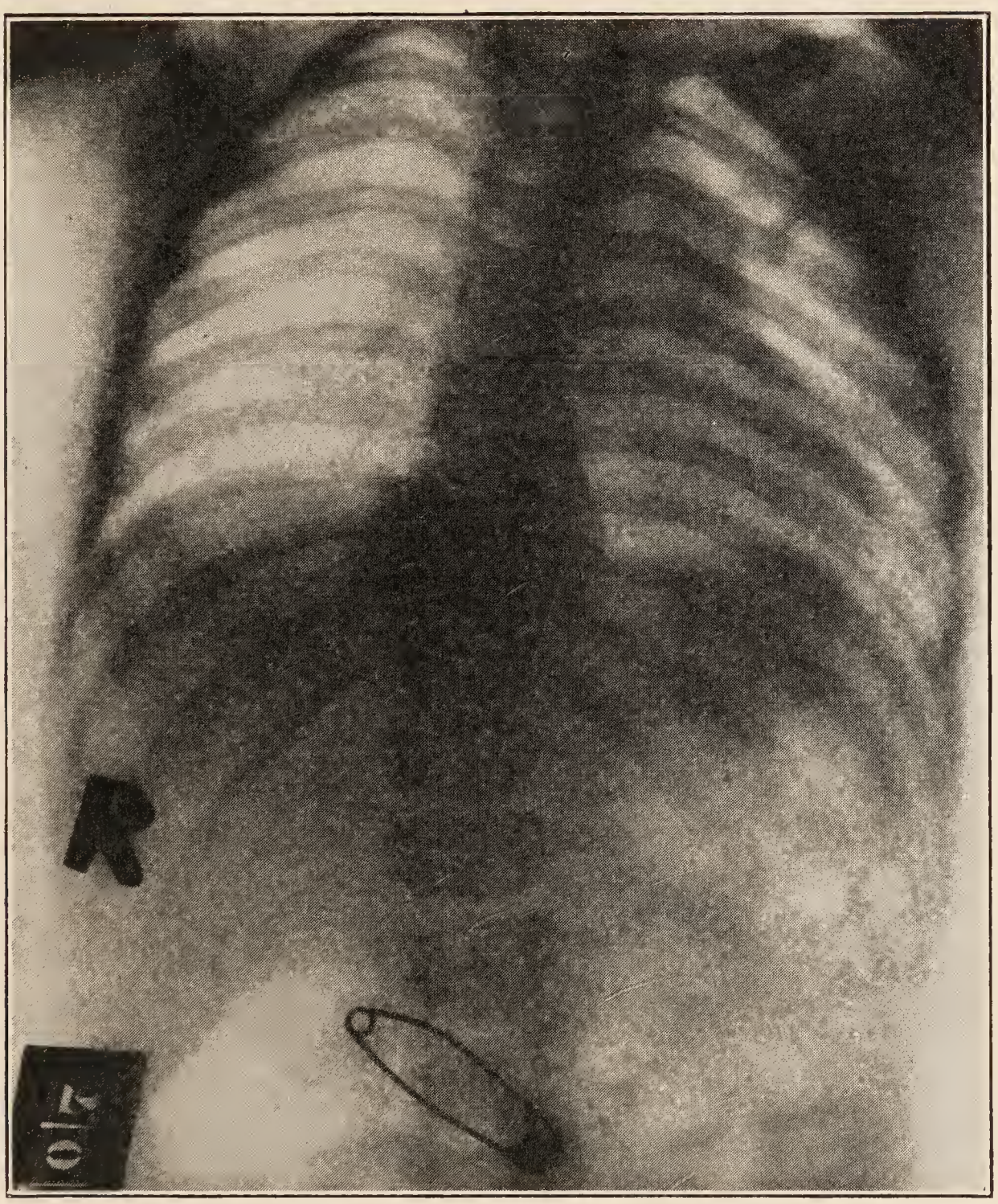


FIG. 127.—Case of tuberculosis of the spine, showing loss of the normal outline of the bodies and discs, at the 9th 10th, 11th and 12th dorsal vertebrae. Note bilateral abscess shadow. (*Courtesy of Doctors Lutz and Bowers.*)

posterior mediastinum in suspected abscess of the dorsal region. Careful palpation in beginning curves of the most prominent spinous process may show that it is more movable than the adjacent ones, owing to the softening and disintegration of the intervertebral ligaments and may elicit pain.

In doubtful cases a blood count and X-ray photograph are to be used to help clear up the diagnosis. The former giving negative information as the

red cells show a secondary anaemia in advanced disease only and leucocytosis of the white elements *only* in secondary infection of tuberculous abscess cavities by the pyogenic bacteria. The X-ray, on the other hand, shows *a clouding of the tuberculous area, loss of the quadrilateral shape of the vertebral bodies* and *absence of the clear spaces, which indicate the intervertebral cartilages* (Figs. 127, 128 and 129). The subcutaneous tuberculin test can be used *only* in conjunction with *several of the clinical symptoms* above mentioned, for otherwise a positive

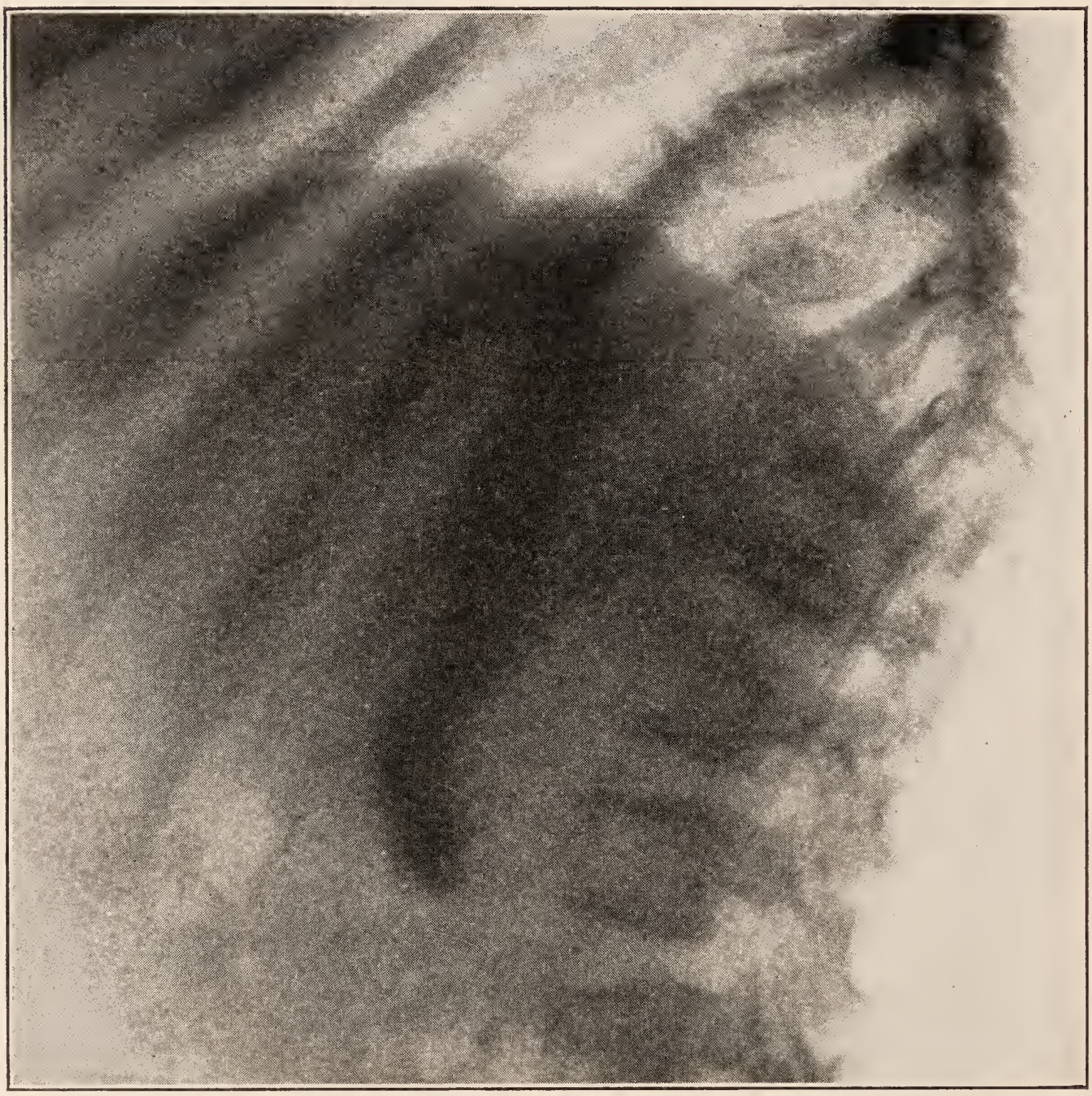


FIG. 128.—Lateral view tubercular caries of the 11th and 12th and 1st lumbar vertebrae with collapse and triangulation. (*Courtesy of Doctors Lutz and Bowers.*)

reaction, viz: an elevation of 2° over the usual temperature and chilliness, nausea, headache or muscular pains would not locate the tubercular disease; too small a dose will not give the reaction; other diseases may give a positive reaction, and the author considers it of less value as a means of diagnosis in this manifestation of tuberculosis than the X-ray. There may or may not be increase in the acuteness of symptoms referable to the point of disease. On the other hand, it is a good rule to have the intradermal test (Von Pirquet) done as a routine to confirm clinical and X-ray findings.

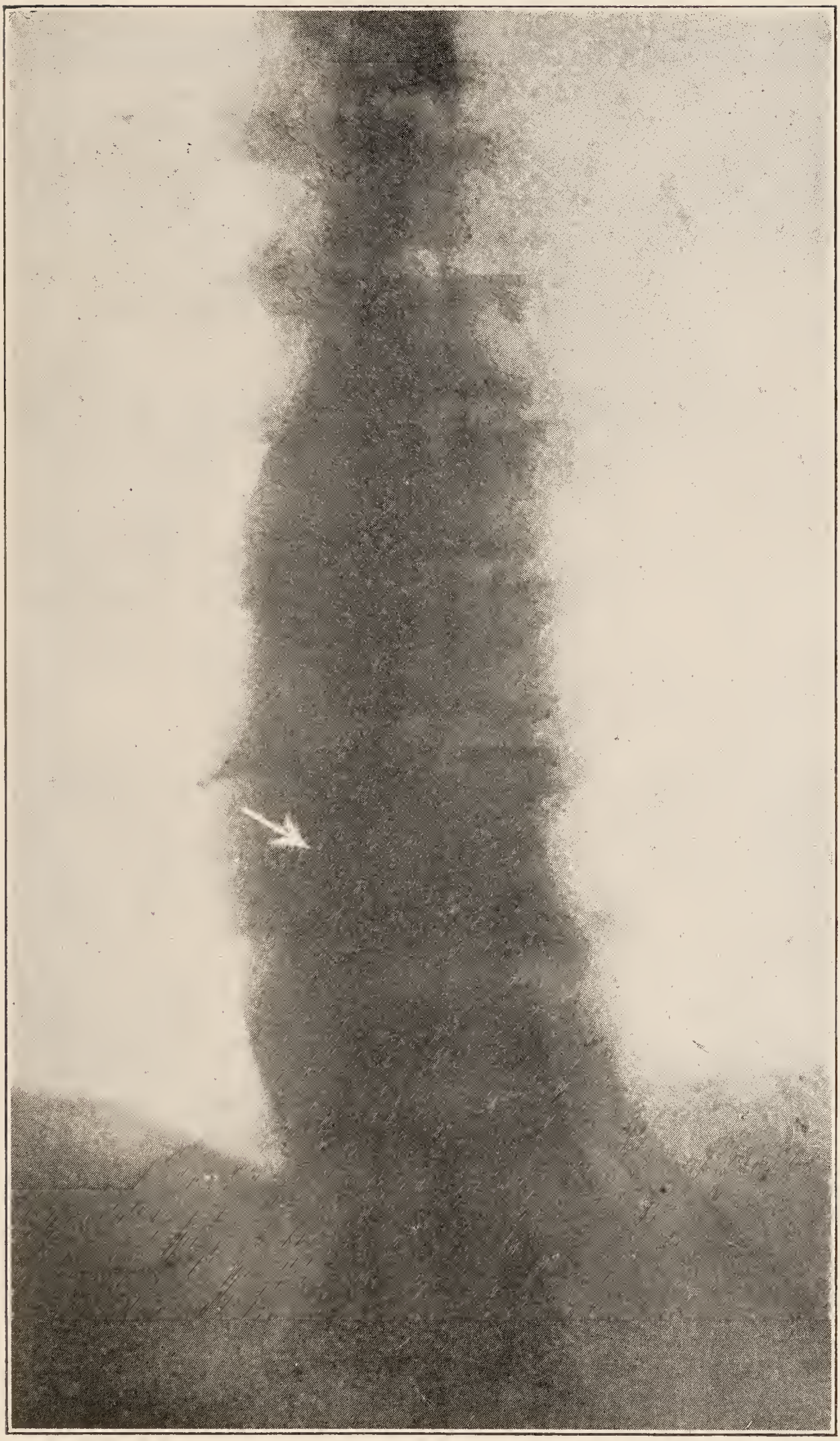


FIG. 129.—Antero-posterior radiogram, also narrowing of 8th and 9th intervertebral discs, showing abscess on left side from 8th to 12th dorsal vertebra.

Differential Diagnosis.

1. **Torticollis.**—In simple chronic torticollis, the contraction is more commonly of the sterno-cleido-mastoid and trapezius muscles, predominating at any rate and no pain is present. In caries all the muscles are contracted, especially the posterior cervicals and deep groups. The patient also in beginning and acute caries of the cervical vertebrae supports and protects the head from jar and cannot move it in any direction without pain.

2. **Functional neuroses, railroad spine, typhoid spine,** etc., are rare in children. In these conditions we find tender points over the spines and usually get a history of traumatism or previous disease. In caries this tenderness over the spine is not the rule and the characteristic deformity and muscle spasm are present even at an early stage.

3. **From Trauma, Rheumatism, and Strain in Children the Diagnosis of Pott's Disease is to be Made with Caution.**—The former tend to spontaneous recovery, while caries untreated gets worse. In adults caries is rare as compared with its frequency in children. It is to be borne in mind, however, that the pain and other symptoms of tuberculous spondylitis quiet down also with treatment, so that suspicious cases should not too soon be considered simple sprains and ample means of diagnosis should be availed of. One sees occasionally rupture of the posterior spinous ligaments and the diagnosis of this condition can be made by the greater separation of the spinous processes at a point of tenderness after injury (Painter). True rheumatism often has a family history of that disease, the temperature is higher than in Pott's Disease, the onset is sudden and other joints are involved. Teeth, tonsils or other focus is found at fault.

4. **Rickets** shows a longer curve in the dorso-lumbar region. It may be sharp and angular, however, with some spinal stiffness, but the other signs of rickets are present and the children are very young. Pain and night cries are absent.

5. **Lateral Curvature** following tubercular osteitis does not show so much rotation of the ribs as in the simple form due to muscular atony. It is usually a late symptom, but may be early and associated with the other symptoms of Pott's Disease, however. In early cases, several careful examinations may be necessary to establish a diagnosis, between the muscular or tuberculous forms of slight scoliosis.

6. **Tubercular Hip Disease** gives a limitation of flexion, adduction, abduction and rotation as well as of extension of the thigh, which last is the only motion of the hip joint limited in dorso-lumbar caries with the exception of possibly rotation.

7. **Carcinoma of the Spine** rarely occurs in children and in adults is a secondary manifestation of cancer elsewhere. It may have all the symptoms of tuberculous spinal disease, but is so very unusually seen that other signs of malignant disease elsewhere in the body would attract one's attention first.

8. **Primary Sarcoma** in children is one of the rarest of diseases and may be eliminated from ordinary consideration.

9. **Meningeal Tumors** cause paralysis of various forms, but do not affect the vertebral bodies, except late in this disease by absorption, only then causing changes in attitude and carriage. The diagnosis is to be made by the clinical history.

10. **Aneurism** with absorption of portions of the vertebral bodies is to be diagnosticated by auscultation, which means of diagnosis should be availed of in orthopaedic practice as a routine, as well as inspection, palpation, percussion, etc.

11. **Primary Gummata** of spinal vertebrae are not recorded, as the more usual osseous specific lesion is periosteal or at the junction of epiphysis and diaphysis in the long bones, associated with enlarged spleen and glands and secondary anaemia. On the other hand, in Charcot's Spine associated with other luetic joints, we may have softening of the vertebral bodies, which call for braces or supports similar to those used in Pott's Disease or preferably an Albee Bone Graft. As is well known, this condition is frequently associated with Tabes Dorsalis.

12. **Rheumatoid Arthritis** may have stiffness of the spine and pain in the area of exostoses and peripheral nerve distribution, with a less degree of muscular spasm and no characteristic projection of the spinous processes. The cervical spine is most usually attacked in this disease, but the ribs may be ankylosed to the spine in the dorsal form, so that the chest cannot expand well, or the whole spine may be involved. It is more commonly a disease of advanced life, chiefly in women, than of childhood.

13. **Acute Processes** such as perinephritis and appendicitis, tuberculous and acute pyogenic sacro-iliac disease and caries of the sacrum show only one or two of the symptoms of spinal caries and should never be mistaken for it. After a careful study of the clinical picture and the X-rays, errors in diagnosis should not be made. The acute processes are diagnosticated from Pott's Disease by high leukocytosis, sudden onset and the high temperatures present. Muscle spasm in the abdominal muscles and psoas may be present.

14. **Sacro-iliac Strain** or **Sacro-iliac Subluxation** and so-called "Sciatica" are very common traumatic conditions usually attributed to lifting. As symptoms, one observes usually weight bearing on the leg of the opposite side, muscle spasm and limitation of motion of side-bending of the spine to the side opposite the injury. Lateral leaning of the whole trunk (scoliosis) is frequently seen toward the affected side. When the patient is supine, flexing the leg at the hip, with the knee fully extended, leads to sudden sharp pain down the distribution of the sciatic nerve on the back of the thigh or calf or even to the sole of the foot. The explanation of this is that the nerve is put on the stretch and its component filaments are supposed to impinge on the sharp edge of the subluxated sacrum or ilium at the sacro-iliac synchondrosis. The X-ray shows but little, if anything, in the majority of these cases, even in stereoscopic plates. Occasionally one may notice a wider separation between the sacrum and ilium at the suture line, but this is by no means the rule. Like many other sprains, if neglected or undiagnosed, these conditions lead to a chronic painful condition and one which becomes a serious disability. The condition may be bilateral. Of course, the X-ray shows nothing in common with Tuberculous Osteitis of this joint or of the Vertebral Bodies. We may have here an infectious arthritis with bone spurs.

15. **"Sacralization of the Fifth Lumbar,"** where one or both side may asymmetrically articulate with the ilia or in those cases where the Transverse

Process on one side congenitally by overgrowth and from hypertrophic hyperplasia following slight trauma or even fracture, may impinge or articulate with the crest of the ilium, lead to symptoms identical with those of Sacro-Iliac Strain. In fact, when the former condition is present, Sacro-Iliac Strain is produced and is readily recognized by a careful study of the X-ray, which could never be confused with a tubercular condition. If the X-ray shows apparent articulation



FIG. 130.—Sacralization of the fifth lumbar vertebra. (*Courtesy of Doctor J. F. Lutz from the X-ray laboratory of the Hebrew Hospital.*)

from overlapping bone shadow, another X-ray should be made with the rays falling obliquely from the opposite side to show up the true interval if one exists or stereoscopic plates should be studied (Figs. 130 and 131).

Prognosis.

The prognosis for spontaneous recovery in untreated cases of Pott's Disease is good, though tedious and the symptoms may be severe and deformity extreme. With efficient treatment the prognosis is very favorable. The

mortality is greater in adults than in children, but the statistics as to death from this disease are imperfect, and is given at about 25 per cent. of all cases and perhaps 5 per cent. in the treated cases. The average duration of life is about 50 years.

Causes of Death.—(1) Asthenia from lowered vitality in prolonged disease, torsion or stenosis of the aorta and heart disease; (2) paralysis, rarely; (3) phthisis; (4) amyloid disease of viscera, and (5) fatty degeneration of viscera from prolonged suppuration of secondarily infected abscesses and sinuses; (6) general miliary tuberculosis or tuberculous meningitis; (7) bursting of an abscess into the larynx, lungs, posterior mediastinum, pleura, peritoneum, oesophagus, spinal canal or into a blood-vessel; (8) serious intercurrent disease, such as scarlet fever, on a system already devitalized, have all been reported as causes of death.

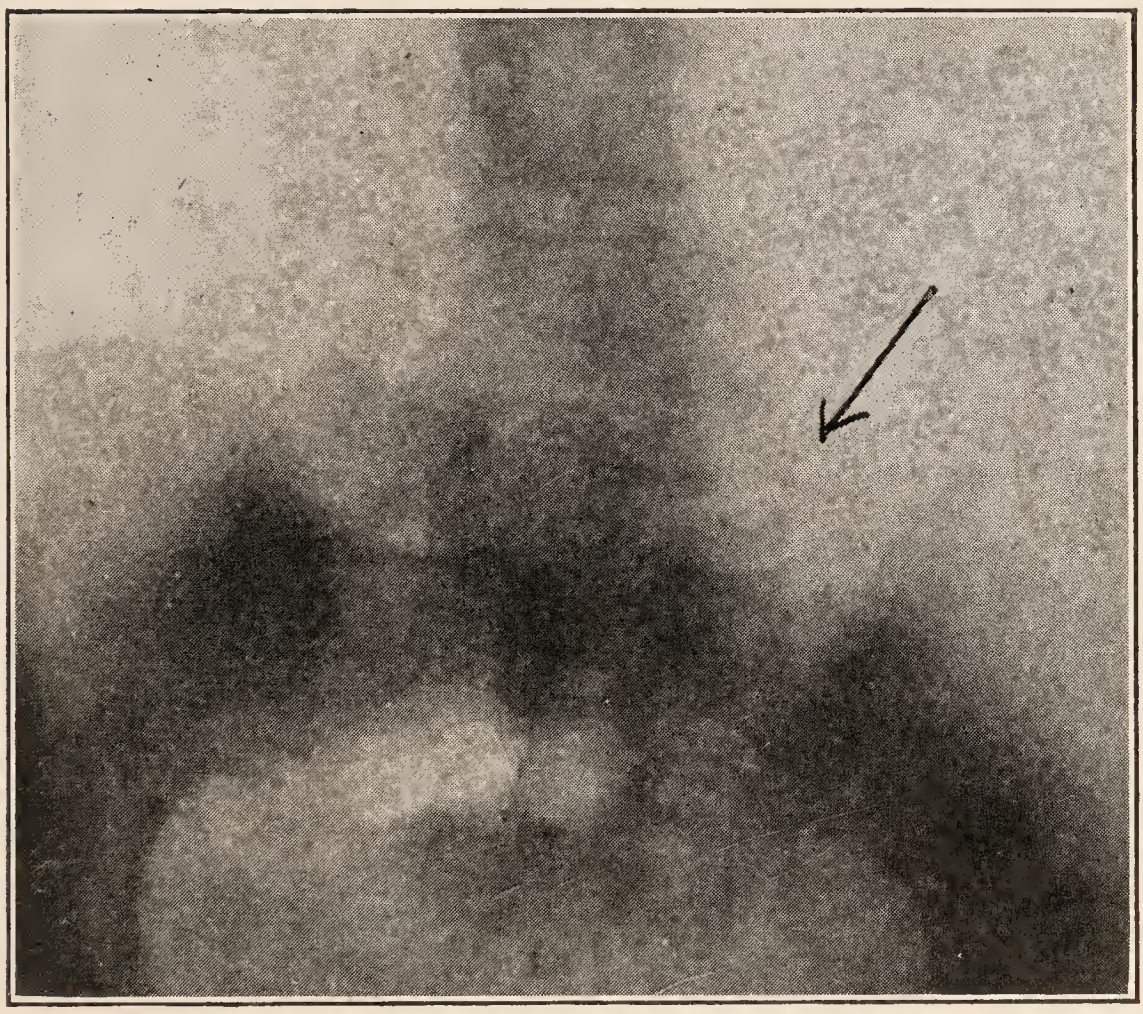


FIG. 131.—After removal of transverse process united to iliac crest, in Author's patient following fall down steps. Sacro-iliac pain on opposite side relieved.

Prognosis as to Abscess.

The chances are 50 to 1 in lumbar disease that secondary abscess will appear, 25 to 1 in dorsal disease and 1 to 50 in cervical disease. From 12 to 25 per cent. of all cases have abscess. Abscess in adults is more unfavorable than in children, but depends on the site, drainage or completeness of evacuation, or upon the vitality of the individual when unopened. Abscess usually indicates severe cases. Psoas abscess with contraction adds to the difficulty of and length of time for treatment. Many secondary abscesses are of such small size that they escape detection in life, as they cause no symptoms. All cases may be said to have abscess, but when the term is used, it refers to one of appreciable size or the secondary abscess outside of the original bone fucus. Phthisis pulmonalis is more common in adults.

Prognosis as to Deformity.

Recession of the deformity is apparent in some cases from ankylosis of the diseased vertebrae and the greater growth of the healthy adjacent ones; the kyphosis is then proportionately less prominent. As a rule, however, the kyphosis increases during the growing years as do the compensatory curves.

Prognosis as to Duration.

The time required for treatment depends on: (1) the general health of the patient; (2) the size, the region and the amount of the spine diseased; and (3) the amount of the superincumbent weight; as a rule not less than three years. Cervical disease naturally takes less long to heal than lumbar. Protection for firm ankylosis requires a long time, especially is this true in growing children. At puberty there seems to be a danger of redevelopment of the symptoms, therefore care and protection of the spine is especially necessary then.

Prognosis in Paralysis.

Prognosis as to the time of recovery from paralysis, under efficient treatment, is from seven months to one year. Recovery may occur suddenly, from the evacuation of an abscess, hyper-extension of the spine, forcible reduction of the deformity with relief of the stenosis of spinal vessels from oedematous pressure, etc.

The prognosis, if sensation is abolished, especially if there is paralysis of the rectum and bladder, is less favorable and very much less favorable in amyloid disease.

The Principles of Treatment.

The principles of treatment are rest and immobilization, which are accomplished by (1) recumbency, (2) traction, and (3) fixation, *with the spine hyperextended* at the point of disease. These principles of treatment are based on the following facts: First, if we review briefly some of the chief anatomical features of the spine we find the vertebral column as a whole consists of four curves when viewed laterally—a convexity forward in the cervical region, a convexity backward in the dorsal region, a convexity again forward in the lumbar region and backward in the sacral (Fig. 191).

The three first-mentioned curves, with which only we are concerned, are subject to variations dependent on whether the individual is standing or sitting, and also whether the observation is made on rising in the morning or late in the evening, being in the latter cases more marked.

It has been shown by Brackett[1] that recumbency in a prone position lessens these curves, and supine recumbency has been used from time immemorial as an efficient means of treating spinal curvatures.

Suspension by the head and hands also straightens out these physiological curves, if we may so designate them. Le Vacher[2] first demonstrated this in 1768, in his "L'arbor suspendens" attached to a corset (Fig. 8).

Very similar to Le Vacher's "L'arbor suspendens," is the "jury mast," for which Lee gives the credit to J. K. Mitchell in 1826, and Lee's own "self-

[1] Bradford and Lovett, Orthopaedic Surgery, 2d ed., 1899, 53.

[2] Memoriors de l'Académie royale de Chirurgie, Paris, 1768, tome 4.

suspension spinal swing," devised in 1866, confirmed this observation in regard to the physiological curves. The student should bear in mind that the jury-mast or l'arbor suspendens are now regarded as crude and obsolete methods of treatment when compared with the modern braces. The elder Sayre is often credited with the jury mast, however, and also the spinal swing. We know now that these physiological curves are chiefly lessened by suspension and not the curves due to tubercular disease, as earlier observers thought (Fig. 146).

In the erect posture, the spine must bear the superincumbent weight of the head and by means of the ribs and diaphragm also the weight of the thoracic viscera, and, to a certain extent, the liver and other abdominal organs. Further, through the sternal attachments of the shoulder girdle and the anterior situation of the arms, there is to a certain extent also a drag downward and forward on the dorsal spine by them.

If the spine, as a whole, is viewed in profile in either a skeleton or a fresh specimen, it will be seen that a vertical line drawn through the bodies of the cervical vertebrae will pass anterior to the dorsal vertebrae, not touching them, but in the lumbar region such a line will again reach the vertebral bodies. Thus, from an anatomical standpoint, we may conclude that the mechanics of the spinal column decidedly predispose to a dorsal convexity, or kyphosis, even without the addition of disease, which the continuity of the vertebral bodies and intervertebral fibro-cartilages antagonize anteriorly and the ligamenta flava, inter- and supraspinalia and muscles posteriorly (Fig. 191).

Secondly. From the pathological findings in caries of the vertebrae since the time of Sir Percival Pott, observers have noted that the less compact bodies of the vertebrae are the seat of the tubercular osteitis, softening and disintegration and not the denser articular and transverse processes, as a rule. As a result of this in untreated, mal-treated and neglected cases, the characteristic deformity has occurred, i.e., the superior and inferior edges of the bodies of the involved vertebrae have come into closer contact anteriorly and the spinous processes are more widely separated than is normal. In addition, unless means are adopted to check this, the healthy vertebral bodies will come into contact with those diseased and from the traumatic irritation produced thereby and the contact with those diseased and from the traumatic irritation produced thereby and the contiguity, the healthy vertebrae will also become involved in the process and so the diseased area will extend.

What, then, can we gather from this, as the indication for treatment to combat this normal and pathological tendency to kyphosis (Fig. 147)? *Hyperextension*![1]

Hyper-extension may be accomplished by felt or hair cushions or padded wooden blocks, or by bending the Bradford frame upward into an arch, as suggested by Whitman, in order to produce lordosis as much as possible at the seat of disease (Fig. 26).

The author prefers the padded wooden blocks under the deformity as enabling one more accurately to localize the hyperextension. A plaster of paris jacket applied in hyper-extension is sometimes necessary in addition to the Bradford frame for the recumbent treatment of restless children (Fig. 133).

[1] R. T. Taylor, Johns Hopkins Hospital Bulletin, Feb., 1895, No. 45.

Traction.

Traction in recumbency for acute cases is most useful. A padded webbing sling under the chin and occiput attached to spreader and cord with a weight of one-half to five pounds is used, or a regular Sayre leather head-sling may be employed. Counter extension in cervical cases is afforded by the body weight on raising the head of the bed. In acute lumbar cases, a double Buck's extension to both legs and raising the foot of the bed will be found useful. Recumbency will be found more applicable and better tolerated in children than in adults. Recumbency should be thorough, fixation perfect and no half measures used, as we then get the dangers and disadvantages of confinement without thorough treatment (Fig. 26).

Traction is employed to relieve pain or paralysis. In paralysis or severely painful cases traction on both the head and legs should be employed. It has been proven, however, that traction cannot pull the vertebrae apart except where the disease is extensive, but it does diminish intervertebral pressure and overcomes muscular spasm. Whether deformity has occurred or not the small firm pads or pillows should be fastened to the undershirt on either side of the diseased region over the transverse processes, or used separately as a padded block of wood with a groove down its center to avoid excoriating the skin over the spinous processes, in order to exert an upward pressure and antagonize deformity, when the child is recumbent and to maintain hyper-extension. Pads of curled hair or the best piano or sadler's felt, are the most useful materials to employ (Fig. 133).

The objections to recumbency are: (1) the confinement; (2) the restlessness of the patient; and (3) it had been said to produce a tendency to meningitis when too long continued, probably from lowered vitality incident to the confinement.

Recumbency is indicated and necessary in (1) acute cases; (2) paralysis; (3) abscess, when painful or causing contractions; (4) those cases which are easily tired; (5) high cervical cases; (6) low dorsal or lumbar disease; (7) as a routine treatment in all cases in the early period of disease and *for a certain period daily throughout the disease.* Even after a week of recumbency improvement is generally noted in appetite, increased weight, absence of pain and improvement in general condition. Recumbency for a month or six months in the early stages of the disease will be found extremely helpful in this disease and should be continued until *all* acute symptoms subside.

Manifestly it is the maintenance of hyper-extension of the spine, as the author was the first to point out,[1] until all danger of extension of the tubercular process is passed and firm cicatrization has occurred with a layer of non-tubercular granulation tissue, which is converted in time into fibrous tissue, cartilage or bone, or a formative osteitis locks the vertebral bodies or processes together inseparably by ankylosis.

I have illustrated this diagrammatically: Let Fig. 132A represent two healthy vertebrae seen in profile. The parallel lines represent the superior and inferior planes of those bodies. The centre of gravity or weight-bearing line is indicated by the dotted line, seen to pass through the centre of the vertebral bodies. The alignment of the spinous processes is seen to be straight.

[1] R. T. Taylor, Johns Hopkins Hospital Bulletin, Feb., 1895, No. 45.

In Fig. 132 B we see the result of an untreated tubercular process where the bodies have collapsed, the planes of the superior and inferior surfaces converge and meet anterior to the vertebral column and spinous processes are widely separated. The centre of gravity line is thrown further forward, tending to

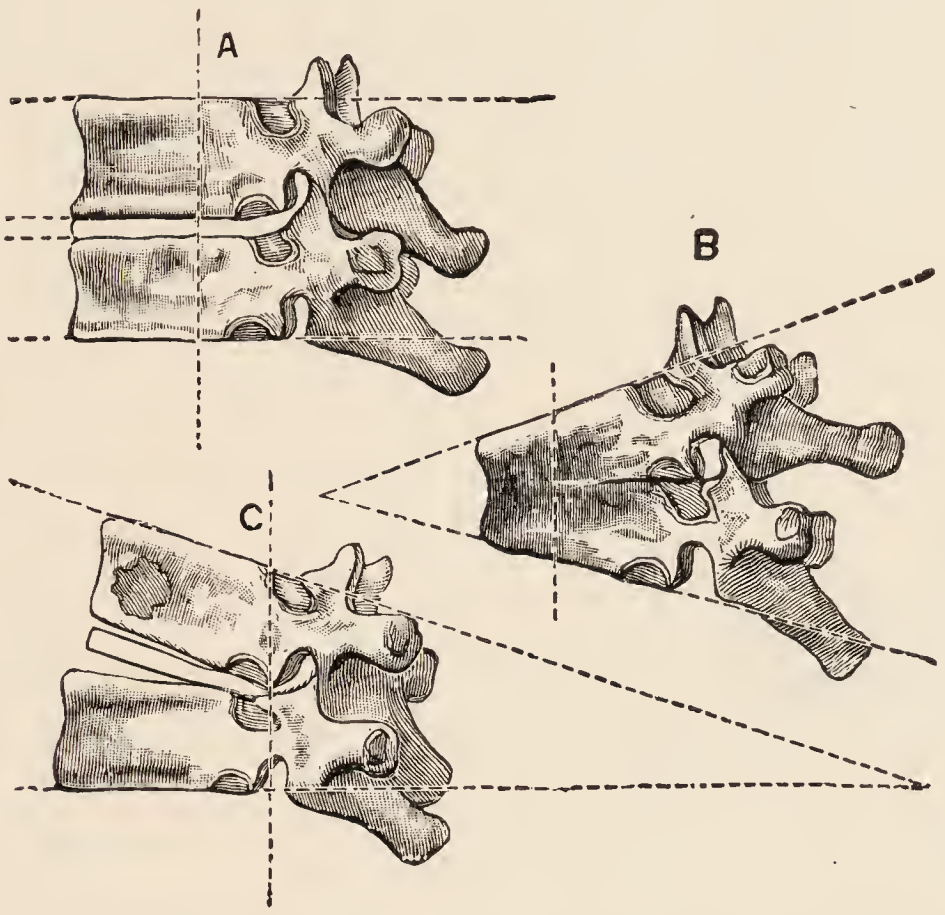


FIG. 132.—Diagrammatic representation of the production of the deformity of Pott's disease. *A* = normal; *B* = Pott's disease; *C* = aim of treatment.

increase the deformity. The separation of the spinous processes shows the characteristic contour of the hump-back.

In Fig. 132C is shown what should be the aim of treatment, viz.: the separation of the vertebral bodies as far as the ligamentous and muscular attachments will

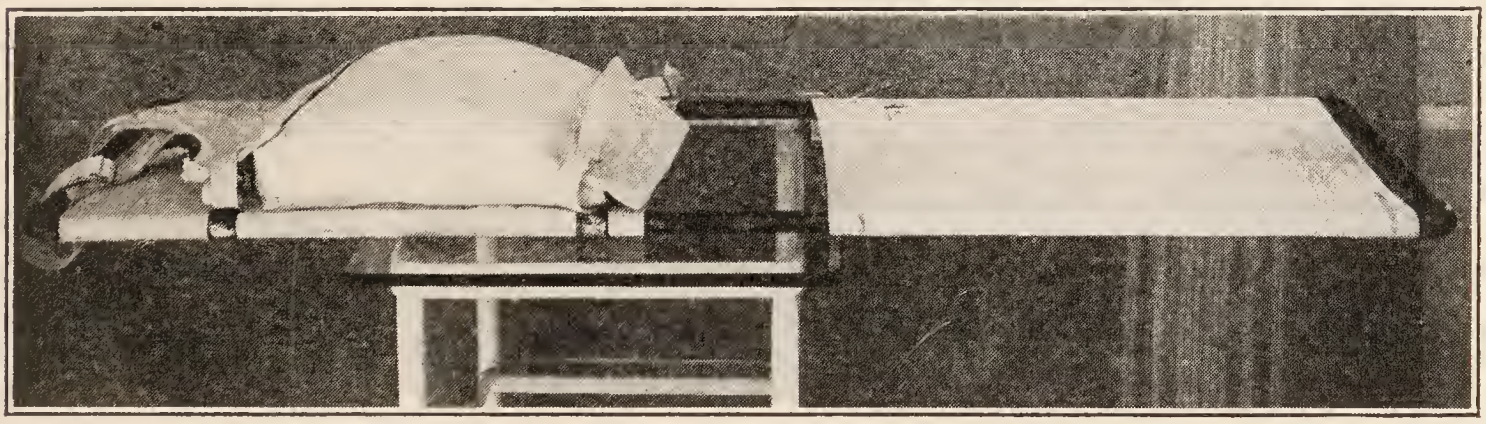


FIG. 133.—Bradford frame, Author's bib, pelvic strap and spring clips together with padded block for dorsal hyperextension (see Fig. 26).

permit, the throwing of the centre of gravity back on the articular processes and the crowding together of the spinous processes.

We cannot say that a true separation of the vertebral bodies really occurs by hyper-extension before extensive bone destruction has taken place, but certainly intervertebral pressure is lessened and in extensive unhealed disease, where softening of the tissues still exists, such a separation certainly occurs in

hyper-extension. With these principles before us we are now in a position to take up treatment in detail.

Recumbency.—The patient preferably out-of-doors on a sleeping porch is to be placed prone on the face or supine on the back on a *firm* mattress; if on the back, the head is to be low and a pad under the deformity is to be used to separate the diseased vertebral bodies as much as possible by hyper-extension of the spine. The patient is not to be allowed to sit up nor lie on the side, as these postures twist and move the spine, nor is the patient to bend forward for such motion crowds the vertebral bodies together producing trauma at the diseased softened area. As a means of fixation or to accomplish the methods laid down above, we may use the Bradford Bed Frame, which accomplishes many of the

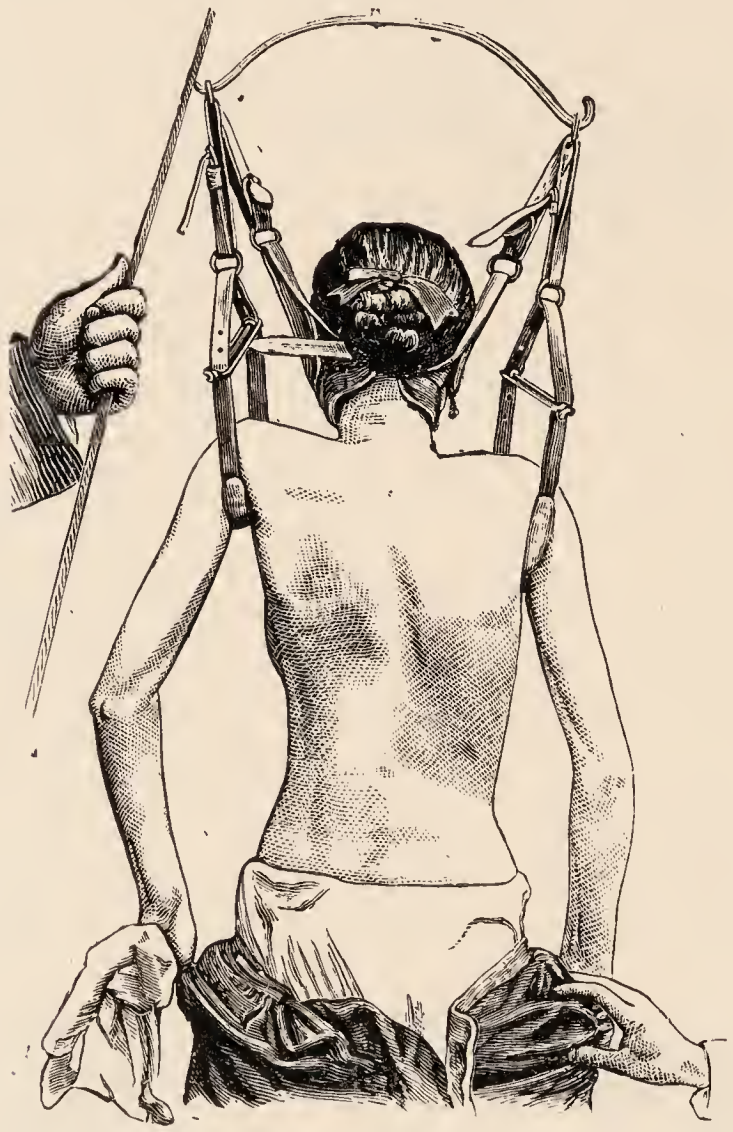


FIG. 134.—Patient suspended ready for the plaster. (*Stimson.*)

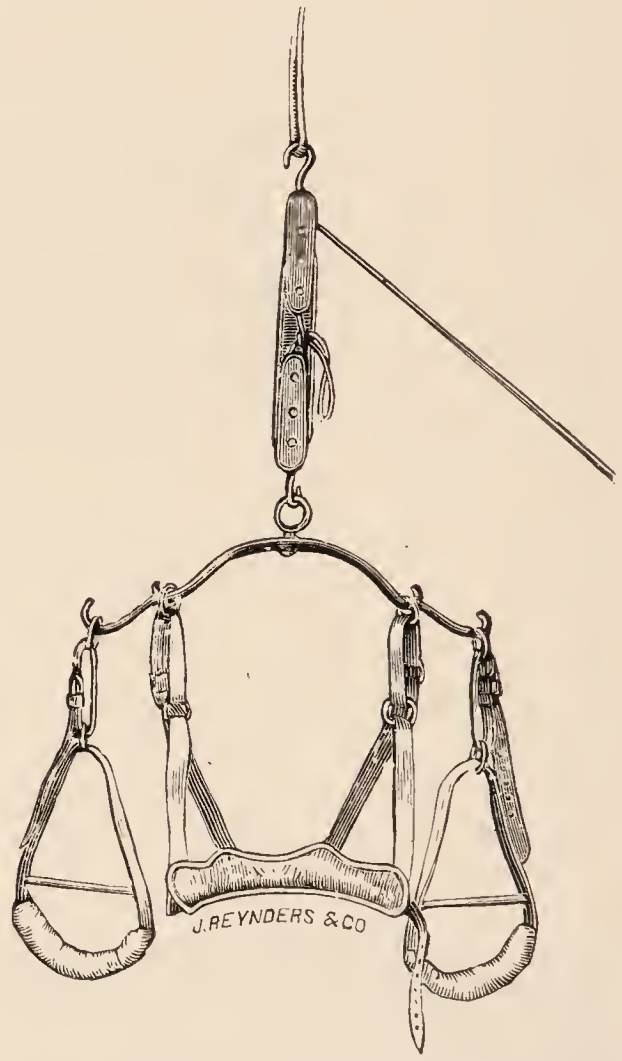


FIG. 135.—Suspensary apparatus for application of the plaster jacket. (*Young.*)

objects to be found serviceable in recumbency; offers the further advantages of making the patient portable and renders out-of-door life on this stretcher more simple.

Treatment by Suspension.

Absolute suspension of the body by the neck, i.e., "hanging," by means of a head-sling can be used only temporarily of course. Continuous head suspension or traction or support, as we may call it, can be obtained and is *always necessary* and to be used in *cervical* and *high dorsal* caries to remove the superincumbent weight from the diseased spine, by the jury mast, the various head supports and collars in conjunction with spinal corsets or *braces to be described later.* This head suspension is a most essential part of treatment in the regions named and without it deformity surely ensues.

Fixation and Supporting Treatment.

This means of treatment is secured by corsets or jackets of plaster of paris, paper, wood, aluminum, leather, celluloid, etc., and the different varieties of steel spinal braces.

There are five methods of applying plaster of paris jackets, (*a*) the Sayre suspension and traction method; (*b*) the Brackett recumbent and extension method; (*c*) pads or support under the chest and pelvis; (*d*) manual suspension, and (*e*) the writers method of partial suspension and hyper-extension with the patient in a sitting attitude, or of hyper-extension and traction while recumbent.

Preparation of the Patient for a Jacket.

Before describing these methods in detail, it may be well to give a few suggestions on the preparation of the patient. The child should be stripped of all the clothes and the body bathed with 95 per cent. alcohol to harden the skin. A summer weight undershirt or seamless stockinet should then be put on that extends well up in the neck and down below the trochanters. It is to be pinned tightly over the shoulders and under the perineum. If any deformity exists, pads of superimposed layers of piano felt, about 1½ inches wide and of sufficient length to extend all along the bony prominence, should be stitched to the shirt over the transverse processes on either side of the affected region and sufficiently close together to prevent the plaster jacket, when hardened, from rubbing and ulcerating the skin over the prominent spinous processes. If this precaution is not taken, a troublesome sore may result. If the child is very thin, it may be necessary to put piano felt pads over the anterior superior spines of the ilia and sternum to prevent excoriation. When this is done, the child is ready for the application of the jacket, which is done with turns of wet plaster of paris bandages. Formerly a pad, called a "dinner pad," was placed over the abdomen and withdrawn after the jacket hardened, but this is unnecessary.

Now, we will consider methods of applying plaster of paris jackets. There are many different ways of accomplishing this, which the author has found useful, depending on the case.

(*a*) **The Sayre Method.**

The oldest or (*a*) Sayre method makes use of an apparatus consisting of a head-sling and straps which pass under the axillae; these are supported by a spreader, which is attached to a rope with a pulley in the ceiling by means of which the patient can be suspended and any desired degree of traction made and the jacket applied. Formerly, it was considered by some, that it was possible to straighten out the deformity by this suspension; this, however, is not the case; the superincumbent weight is removed and the spine is lengthened in so far as the physiological curves are straightened out, but the pathological curves are not. The jacket acts as a means of fixation of the spinal column and prevents any bending forward, which would cause additional damage to the already diseased vertebrae. The bandages are simply wound smoothly without tension around the body until the judgment prompts one that a sufficient number have been used to furnish the necessary thickness to support the individual case. If by this method, as may be found, the jacket does not fit

tightly over the sternum, "V's" may be cut out of the top (wide end up) with the plaster knife and the edges of the "V's" approximated by additional turns of plaster bandages. A possible objection to this method may be the nervousness and fright of a child at being suspended or "hung," as they call it, but it certainly is of value in many acute cases for the relief of pain, in that it removes the superincumbent weight. It is also of value in cases where the deformity is due as much to the exaggeration of the physiological curves as to the deformity itself. The chief objection is the unsteadiness and swaying of the patient during the application of the jacket and that it *produces no hyper-extension of the spine* at the point of disease (Figs. 134 and 135).

(*b*) Davy-Brackett Hammock Method.

This method enables us to put a jacket on a patient in recumbency. The apparatus consists of a quadrilateral one inch gas pipe frame, six by three feet in dimension, in which, by means of a screw attached to a one-half inch gas pipe



FIG. 136.—Brackett hammock.

rod passing through one end of a flat hammock composed of two layers of twill cotton, double machine stitched in casings at each end for the ½ inch gas pipe rods; the other end being made fast to the frame, it may be drawn taut; on this the patient is allowed to lie on his face. Slits are made on either side of the patient's body in the twill cotton, usually the portion of the hammock remaining under the patient's body, being sufficiently strong to maintain the weight; it is then a matter of no difficulty winding the plaster bandages around the hammock and patient until the jacket is completed. Difficulty arises in this method from the upper part of the sternum not touching the hammock, so that it is impossible on a tight hammock to have the jacket fit snugly against the *upper part of the thorax*, where it is *so essential to prevent flexion of the spine forward* in its upper dorsal segment, which would manifestly defeat the aim of treatment; this can be obviated in the same way as that suggested in jackets applied by the Sayre method of cutting out "V's" at the top; or the lower part of a jacket may be applied, the hammock cut through at the top and the child held by the arms or shoulders, while the upper part of the jacket is completed, and then the hammock at the lower part can be cut through. This, however, is apt to leave an uncomfortable ridge in the middle. Or a hole can be cut for the face to go

through and thus bring the sternum in contact with the hammock. It is an easy matter to pull out the piece of hammock from within the jacket, if desired, after it is cut across at the top and bottom (Fig. 136).

(*c*) **Chest-pelvic Support Method.**

Two boxes or sandbags or supports of any kind may be used one under the child's sternum when lying face down and one under the thighs and the bandages can then be applied. Manifestly a jacket applied in this crude way should be finished later at the top, when the child can stand, in order to come up high on the sternum.

(*d*) **Manual Suspension.**

A very simple, efficient and ready way, when no other means are at hand, is to have one assistant grasp the child's arms when lying face down, and a second



FIG. 137.—Manual method of applying jacket.

assistant grasp the thighs and swing the child horizontally between them, when the surgeon can apply the jacket. Hyper-extension and a very snug jacket can thus be obtained (Fig. 137).

(*e*) **The Method of Hyper-Extension.**

To meet the aims of treatment, previously outlined, in the latter part of 1894, the author presented before the Johns Hopkins Medical Society[1] what he termed an apparatus for applying plaster jackets on a plaster jacket stool surmounted by a bicycle saddle, on which the patient sat, with the pelvis fixed, the arms extended upward and backward to hand grips dependent from a vertical posterior upright and traction was made on the head by means of a

[1] Johns Hopkins Bull., Feb., 1895, No. 45, and Medical News, Mar. 23, 1895.

head-sling attached to cord and pulley on the posterior upright. The feet were supported on rigid adjustable stirrups. The result of this attitude on the spine was lordosis. In that paper, as far as one can find out in the literature, attention was first called to and the importance demonstrated clinically of *extending*

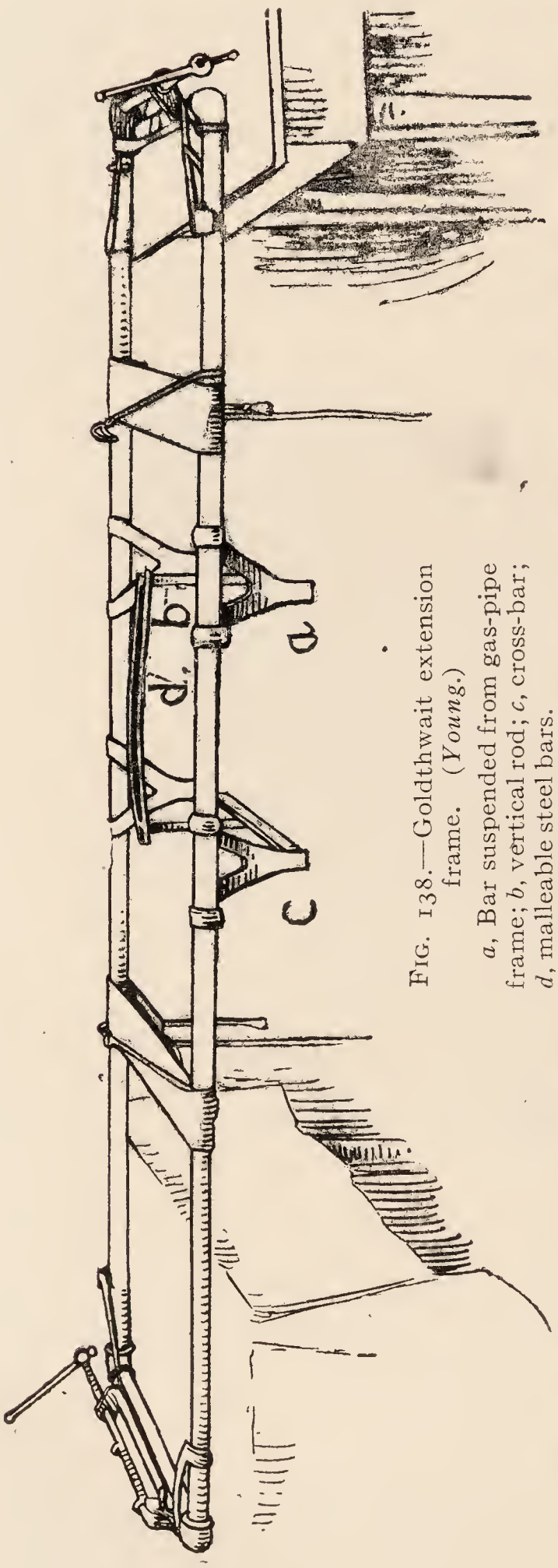


Fig. 138.—Goldthwait extension frame. (*Young.*)
a, Bar suspended from gas-pipe frame; *b*, vertical rod; *c*, cross-bar; *d*, malleable steel bars.

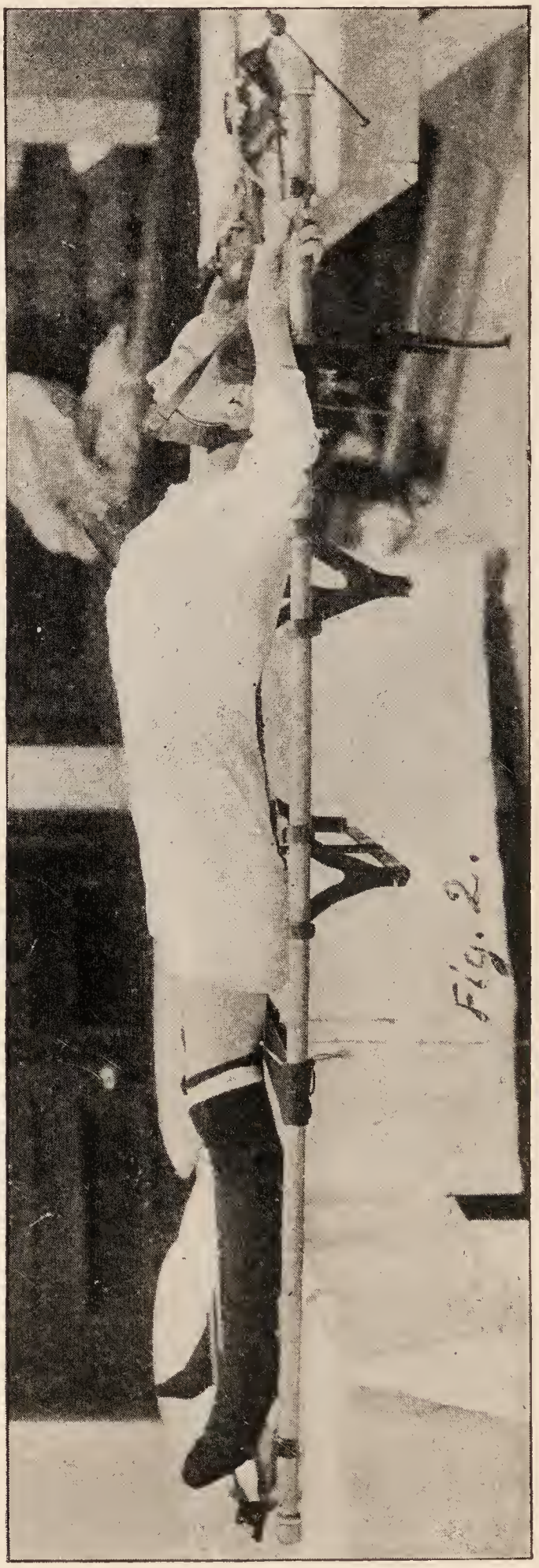


Fig. 139.—Goldthwait extension frame with patient in position. (*Young.*)

the spine backward (*hyper-extension*) *at the point of disease* and the maintenance of this position by means of plaster of paris jackets for the prevention or correction of the natural tendency of the deformity of Pott's Disease. Hadra, in 1891, suggested for fracture but not Pott's Disease the same principle by wiring

the spinous processes together, "thereby relieving the vertebral bodies."[1] Other methods to accomplish the same end were published by other observers shortly after.

Chipault published on March 9, 1895, his method of wiring the spinous and transverse processes in Pott's Disease after "forcible correction" of the deformity under anaesthesia, which consisted in manual traction by several surgeons and assistants on the head and extremities and pressure on the gibbosity, preparatory to applying plaster of paris.

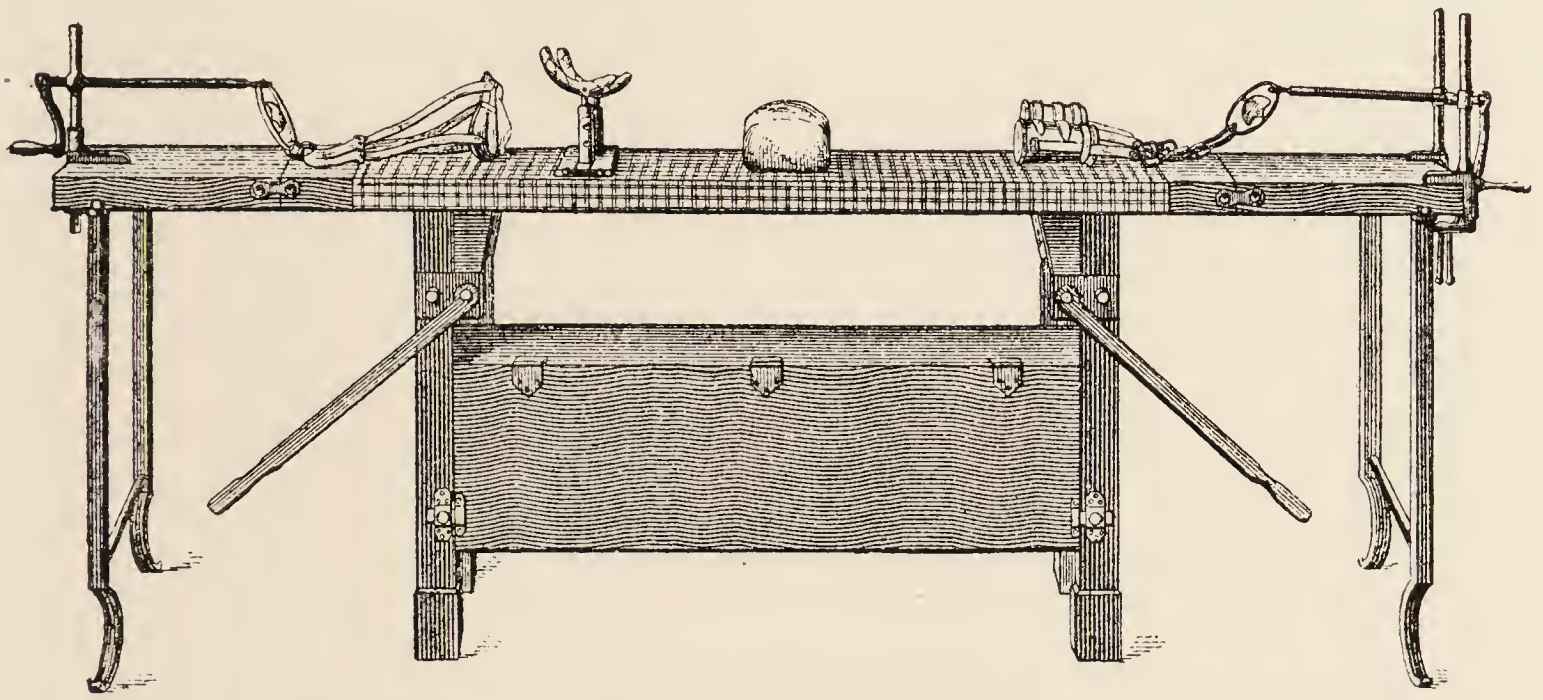


FIG. 140.—Redard's apparatus for forcible correction in Pott's disease. (*Young.*)

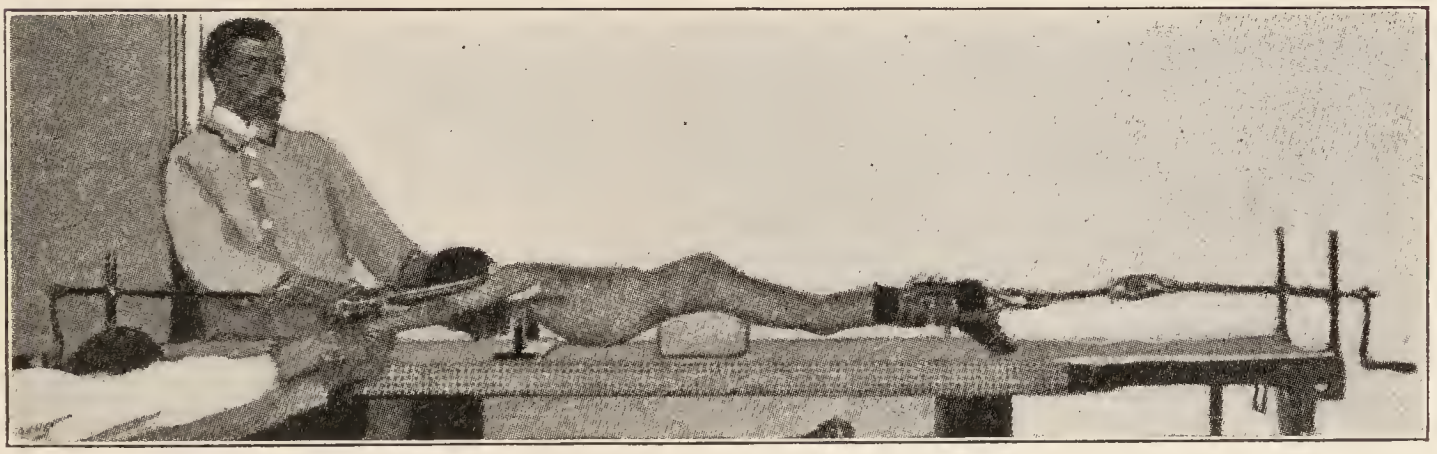


FIG. 141.—Same showing application. (*Young.*)

Calot published a paper on similar operations in 1896[2] and his name and not Chipault's is associated with the operation of "forcible correction."

Goldthwait reported, in 1898, his and Metzger's excellent method of hyperextension, without anaesthesia, in which the patient lies supine on two strips of steel, that portion of the spine above the knuckle being unsupported and gravity acting as the correcting force.[3] The jacket is then applied, and the steels are withdrawn (Figs. 138 and 139).

Redard in the same year published his method of mechanical traction in a prone position with anaesthesia and manual pressure on the boss[4] (Figs. 140 and 141).

[1] Hadra, Trans. Amer. Ortho. Assoc., vol. iv, page 205.

[2] Calot, Trans. Acad. Med., Paris, 1896.

[3] Goldthwait, Trans. Amer. Ortho. Assoc., 1899, vol. ix; Boston Med. and Surg. Jour., July 28, 1898.

[4] Redard, Archivo di Orthopedia, 1898, Fasc. 2

In 1898 the author presented to the American Orthopaedic Association[1] his plaster jacket stool of 1894, supplemented with a pressure rod, to control the point at which hyper-extension was to be made (viz: at the kyphosis) and called the apparatus the kyphotone (*κύφος*, hunch-back, and *τενεῖν*, to extend).

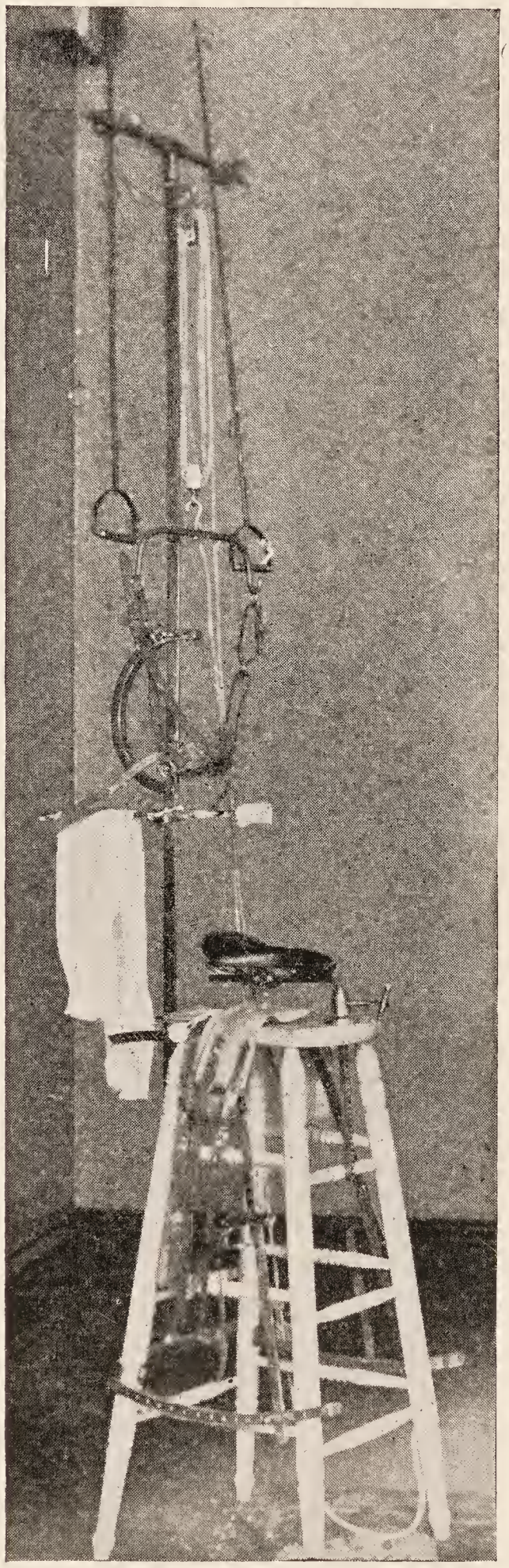


FIG. 142.—Upright kyphotone.

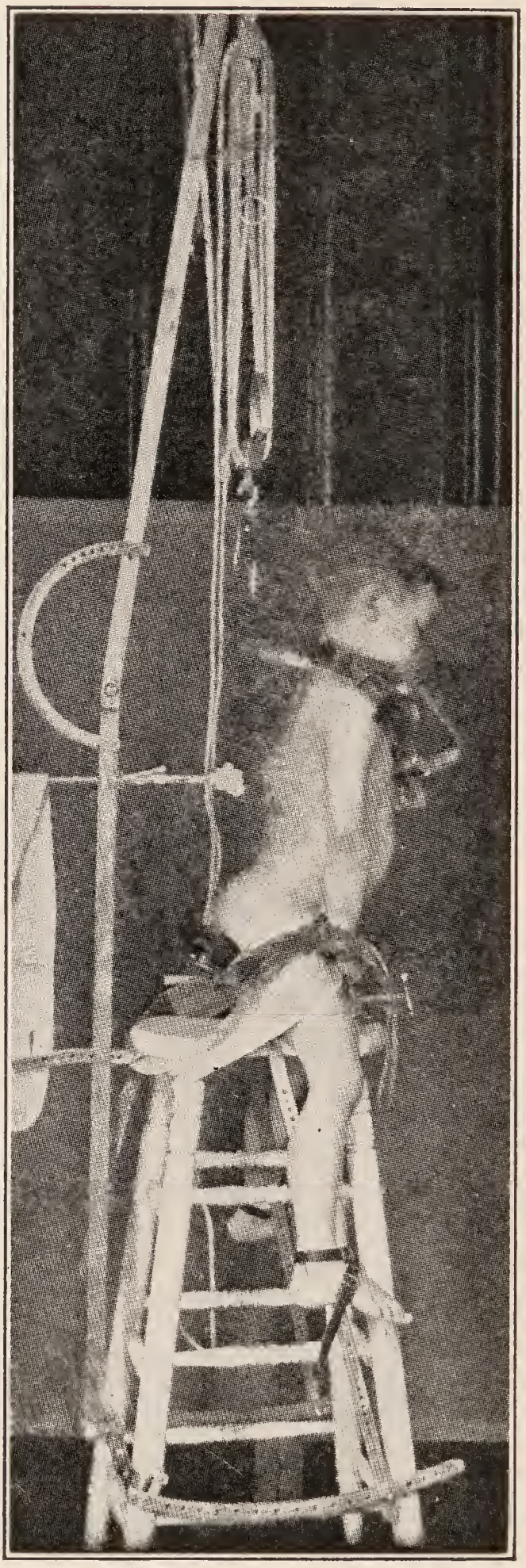


FIG. 143.—Upright kyphotone, showing a case of Pott's disease.

It has been found that without pressure on the knuckle in mid-dorsal cases, the lordosis, or hyper-extension, frequently was more marked in the lumbar region

[1] Trans. and N. Y. Med. Jour., May 12, 1900, vol. xii, page 716.

than in the region of disease and more marked than was desirable, but the pressure rod on the knuckle obviated this, making *the region of the gibbosity* the centre of this arc (Fig. 144).



FIG. 144.—Same case with kyphotone in action.

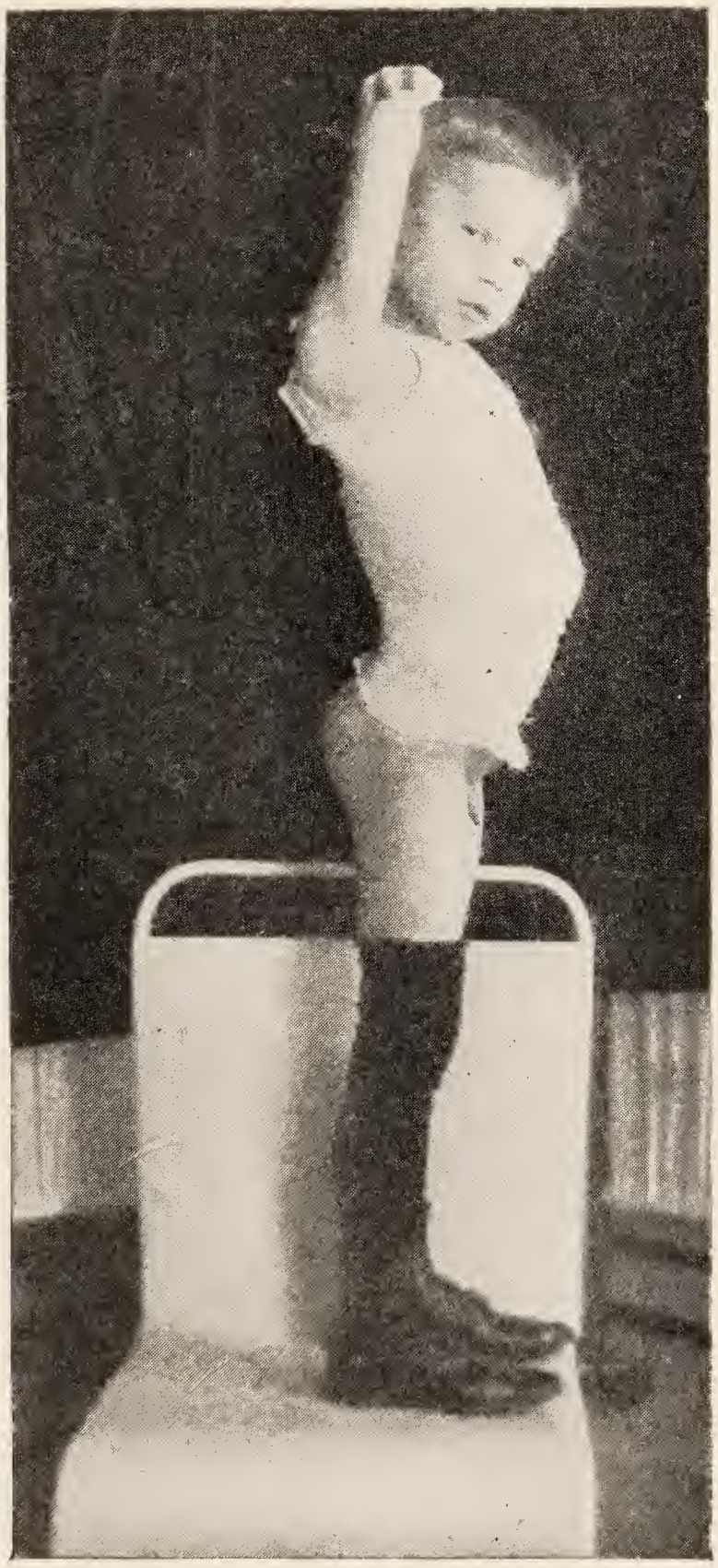


FIG. 145.—Same case with resulting jacket and correction of deformity by "Figure of 8," "Summer jacket."

The comparative value of suspension and hyper-extension in the correction of the deformity of Pott's disease is well shown in photographs. In a double photographic exposure the lower photograph shows the child sitting on a kypho-

tone and the large knuckle is well seen against the back-ground. The upper photograph shows the child suspended by the Sayre head-sling only and the knuckle is virtually of the same size it was before traction was made. In another picture of the same child, taken at the same time, we see traction has been made on the head, the arms have been carried upwards and backwards, the pelvis has been made fast by the wide webbing strap and the pressure rod has been applied, causing *hyper-extension at the knuckle*, with the result that the *spine is virtually straight* (Figs. 146 and 147). In Fig. 148 we see this patient cured with a straight spine.

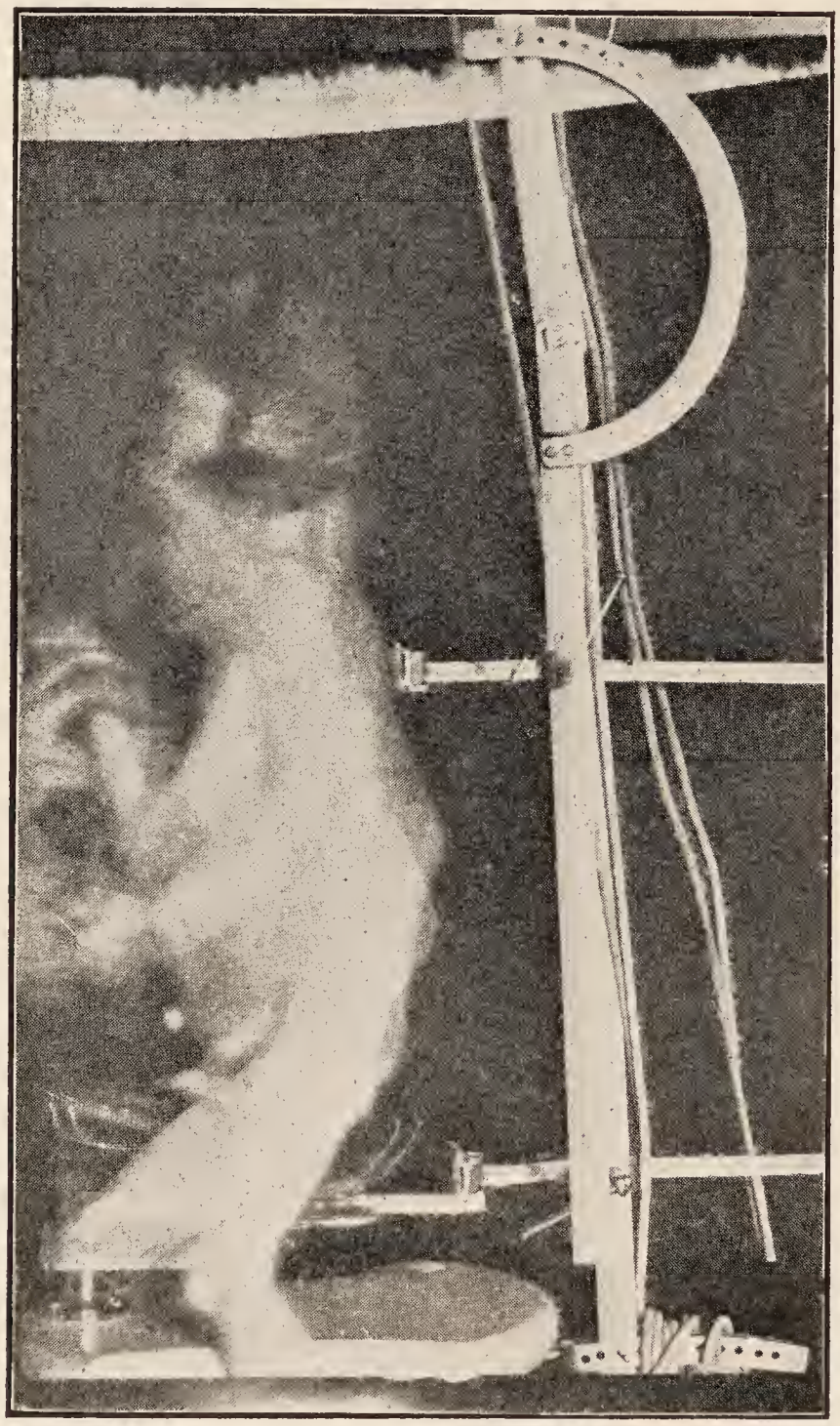


FIG. 146.—Double photographic exposure of a case of Pott's disease without and with traction of the spine, but no hyper-extension. The deformity is unchanged.

The author presented also two recumbent kyphotones at the same time, which carry out the same mechanical principles of hyper-extension.

The larger is similar in many details to the one attached to the office stool, but differs in having the patient lie in a supine position on a plate or pelvic crutch instead of sitting up. The main bar slides in a solid metal block and thus can be lengthened or shortened to adapt itself to the patient's size. The pressure rod, attachments for hands and head-sling are similar to the upright kyphotone (Fig. 149).

The smaller kyphotone is quite simple, inexpensive and can be easily taken apart and carried in a satchel to a patient's house. It consists of two solid bases and uprights, one surmounted by a plate of sufficient size to support the pelvis and the second by a small plate to press upwards against the knuckle, when the patient lies supine. The small plate is adjustable and can be raised or lowered to increase the pressure on the kyphos and vice versa. The distance between the uprights can also be regulated by a rod attached to the bases by set-screws

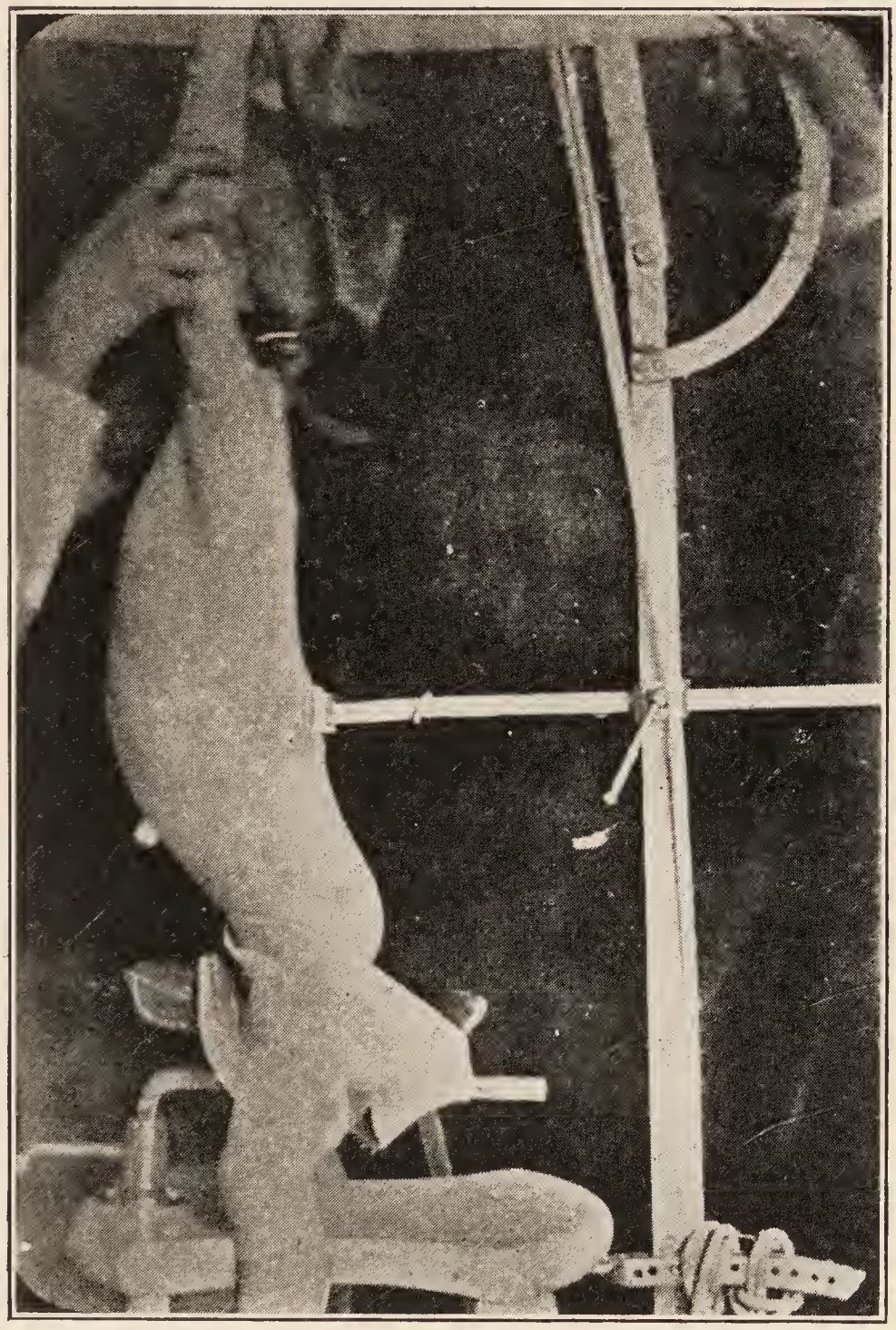


FIG. 147.—Same case as shown in Fig. 146, showing result of hyper-extension made at same sitting.



FIG. 148.—Same boy as shown in Fig. 146, as he is today. Cured without deformity.

(Figs. 150 and 151). The plate of the pressure rod is incorporated in the plaster jacket during its application but can be easily slipped out after the patient is removed from the machine by making an incision on one side of the pressure rod in the plaster, which at this stage has not entirely hardened Then the opening thus made can be entirely and easily closed by molding together the moist edges. Or preferably the patient is pulled upward or forward

depending on which kyphotone is used, as the bandage is rolled between the plate and the spine (McKim's modification).

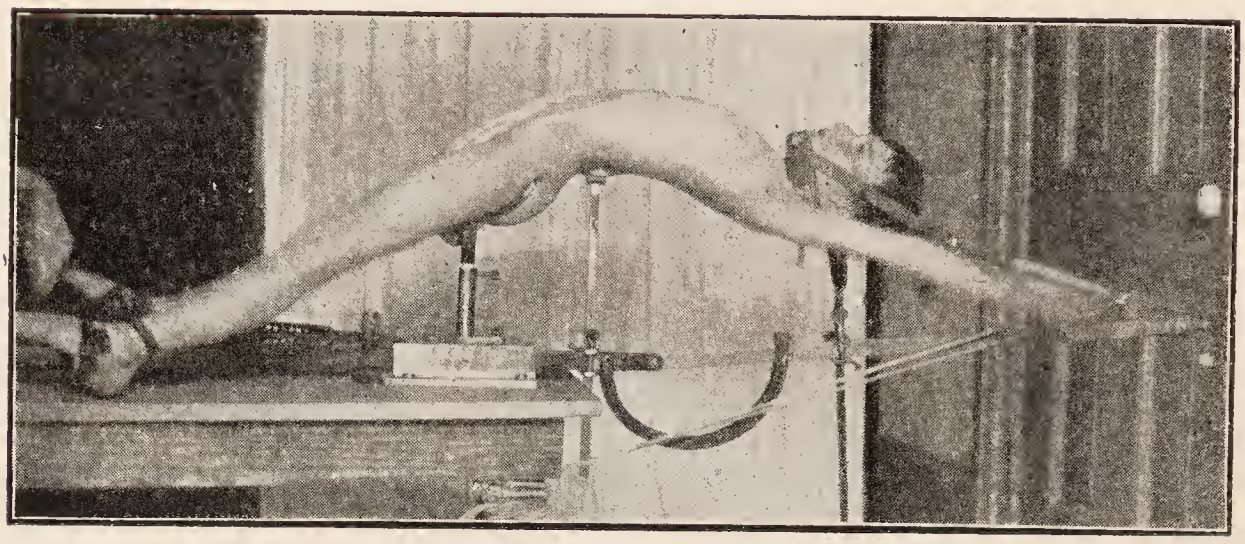


FIG. 149.—Large recumbent kyphotone in action (see also Fig. 37).

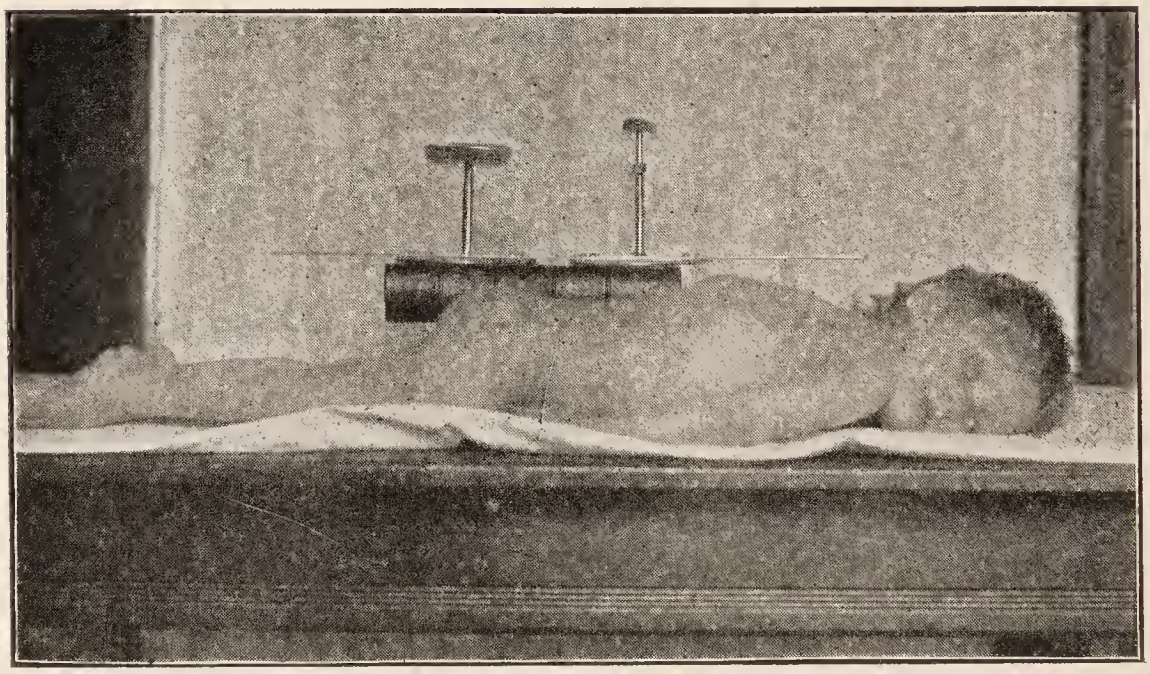


FIG. 150.—Small recumbent kyphotone.

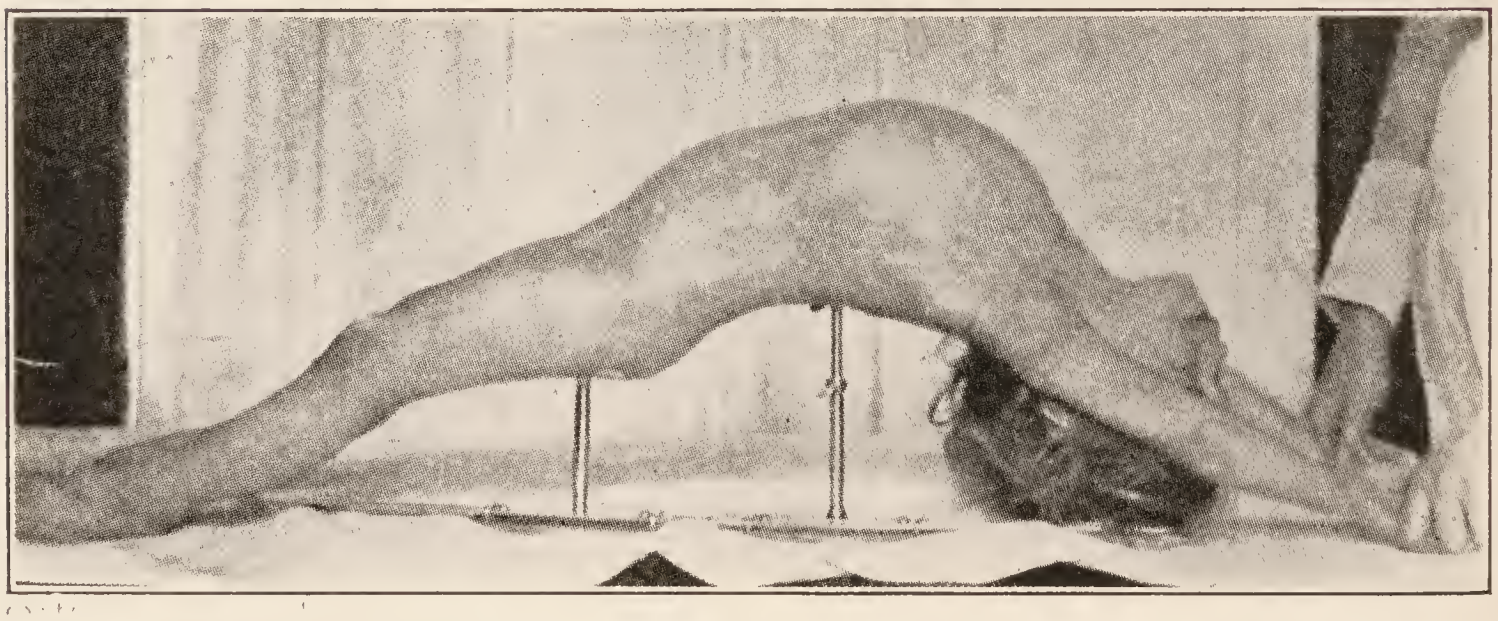


FIG. 151.—Small recumbent kyphotone in action. Same child as shown in Fig. 150.

Both of these recumbent kyphotones were made to meet the need of acute or early cases or those with external pachymeningitis with paraplegic symptoms,

in which it is detrimental to even sit up momentarily, until the head-sling is adjusted and the superincumbent weight removed.

The question of which of these machines we shall use to prevent, correct or improve the deformity of Pott's disease depends on the pathological condition we find in the spine as shown by its flexibility, the size of the knuckle not necessarily being a determining factor of the latter; in other words, *prior to ankylosis, the spine can be made much straighter,* by hyper-extension at the point of the kyphosis (Fig. 148).

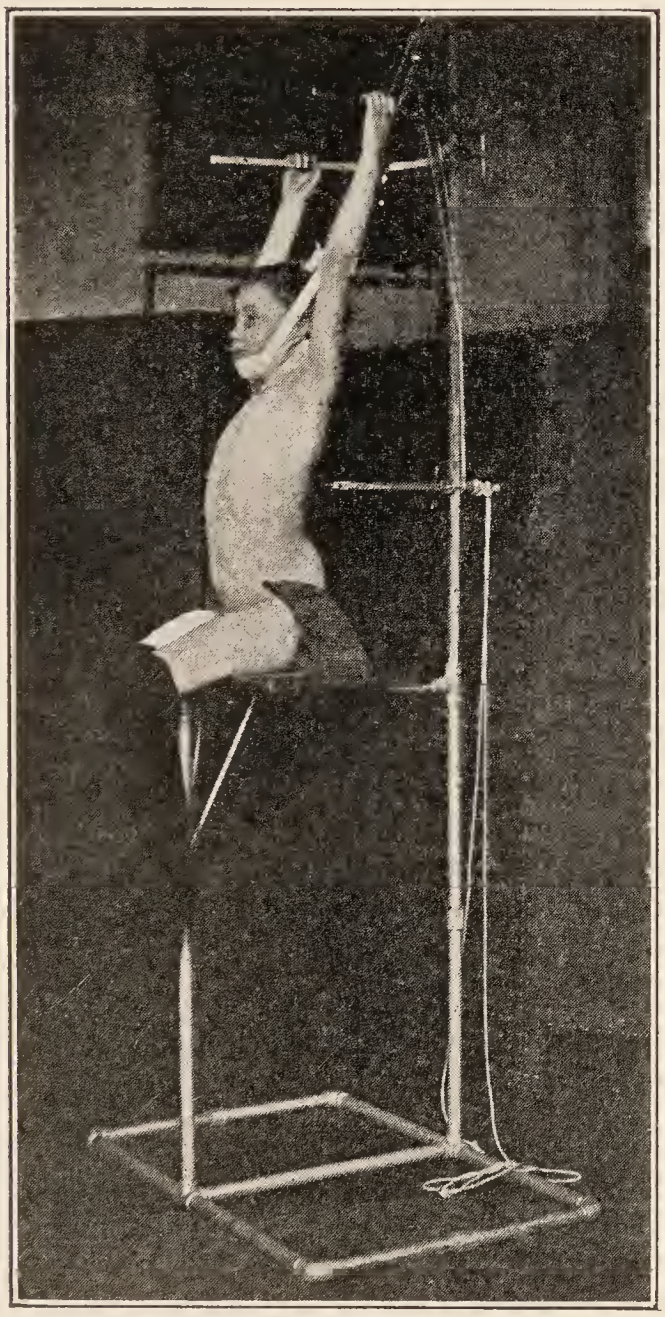


FIG. 152.—Inexpensive upright kyphotone.

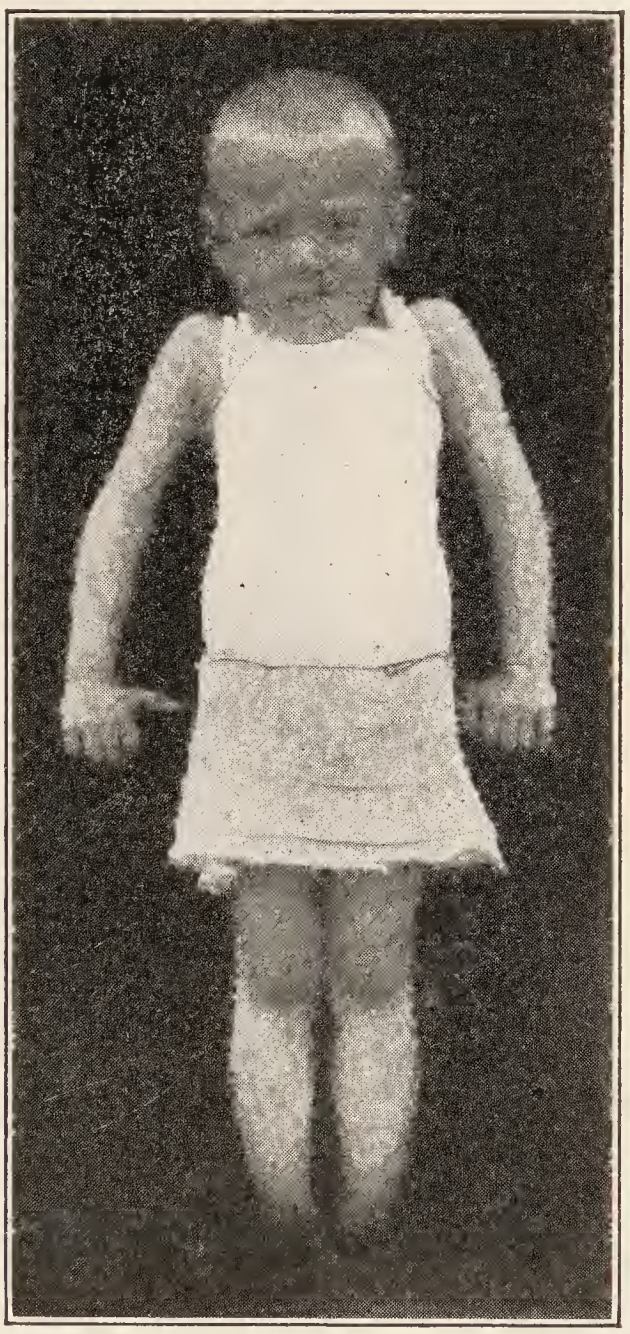


FIG. 153.—A well applied cast.

1. **Earliest Stages.**—At this period there is little or no deformity to correct, but the child will indicate by its posture, carriage or grit, grunting respiration, pain, night cries, muscular spasm or some of the characteristic symptoms, that spinal trouble is present. The region can be located and prevention of deformity obtained by plaster jackets applied in slight hyper-extension on the small recumbent kyphotone.

At this stage caseation and conglomeration of the tubercles is beginning and traumatic contact from pressure of the healthy adjacent vertebrae is ripe to help break down the diseased vertebral body.

2. **Beginning Deformity.**—In such a case the vertebral body has partially broken down and abscess formation has begun. Correction may be obtained

by gravity with the small or large recumbent kyphotone or upright kyphotone and maintained by a plaster jacket.

3. **More Advanced Cases.**—In a case in which several vertebral bodies have broken down, and in which some adhesions or fibrous ankylosis are just starting to form, either the large recumbent or preferably the upright kyphotone may be necessary to correct, with head-sling traction and pelvic fixation. This method affords relief and it is an exception to find a patient tearful during the application of a jacket. It is at times astonishing to see a large hump disappear under this treatment, perhaps not at one sitting but by degrees, as a series of jackets are applied month after month (Fig. 154).

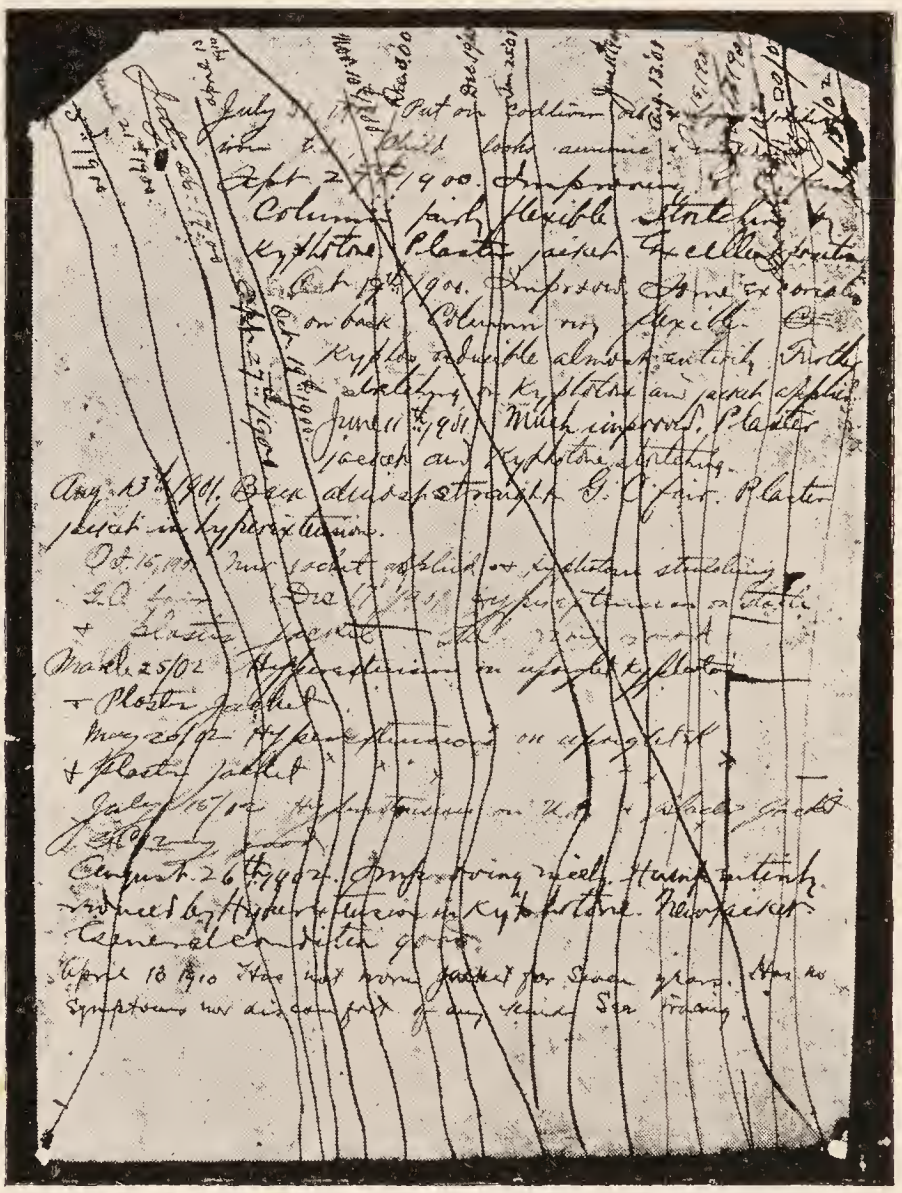


FIG. 154.—Typical out-patient history card showing tracings of the recession of the deformity with treatment. Records made by different externes.

4. **Neglected or Ankylosed Cases.**—If the ankylosis in a case is solid and condensing osteitis has taken place, no extreme force is justifiable. Pain should be the guide to the amount of pressure or traction force used. Even, however, in large knuckles or humps, it may be found the ankylosis is not so solid as one would be led to think and it is certainly justifiable to lessen the deformity of such a case by one of the more powerful kyphotones and allow the spine to heal in an improved position.

In low lumbar disease the hammock method may be preferably used or the recumbent kyphotones with a spica on each thigh in very acute cases.

The method suggested by Bradford and Vose[1] would seem also applicable to the first two of the foregoing varieties. This method consists of allowing

[1] Annals of Surgery, 1899, vol. xvii, page 223.

the child to lie on its back and be slung in a position of hyper-extension by a piece of firm cloth passing under the kyphos. This cloth, after passing around the sides and back is attached to a pulley, by means of which the hyper-extension of the spine can be regulated.

An Efficient and Inexpensive Kyphotone.

My original kyphotone was rather expensive and complicated, so that in the summer of 1905 I had made for our Mountain Hospital for Surgical Tuberculosis, by a blacksmith, the one herewith presented for seven dollars and a half, which answers every purpose and which anyone could duplicate anywhere (Fig. 152).

It has a gas pipe base supporting a wooden seat and pelvic clamp with a steel upright holding a horseshoe-shaped hand grip and a pressure rod.

Each of the last two named are easily adjustable for each case by simply turning one thumb-screw on each.

The gas pipe base is three feet wide, two feet deep and three feet high; the posterior upright is four feet long, making the entire apparatus seven feet high. The horseshoe-shaped hand grip is 36 inches long and the pressure rod is 18 inches long.

The seat of wood is 18 inches wide by 12 inches deep, fastened by bolts to the gas pipe and can be moved forwards or backwards, depending on the size of the patient. In the centre of the seat (not shown in the cut) is a buffer of wood, two by four by three inches, which is a point of counter pressure against the symphysis pubis.

From this buffer extend obliquely backward and outward two slots on each side to hold pins and set-screws (under the seat) to fasten the crescent-shaped wooden pelvic clamps.

The ancientlyrecognized position of the thighs at right angles with the trunk lessens any lordosis present.[1]

This tilting upward and backward of the pelvis in correcting lumbar lordosis can be readily accomplished in the other upright kyphotone by having the patient place the feet on the upper round of the plaster jacket stool instead of in the stirrups.

Jackets are of little or no advantage in high dorsal and cervical caries unless carried around the back of the head and neck, which makes a most bunglesome affair to be worn constantly. Calot carries the jacket over the clavicles and also cuts windows over the kyphos for additional padding and windows in front to allow for this to increase the hyper-extension. When the jacket is carried under the chin and occiput and around the neck it is known as a "Grand Calot Jacket." Jackets, as a rule, are best adapted to lower dorsal and lumbar disease, while disease in the upper part of the spine is best treated by the steel brace, which is to be described later on (Figs. 22 and 169).

The advantages of a plaster jacket are: (1) Its thoroughness and firmness of fixation; it is not uncomfortable as a rule; the surgeon is not dependent on an instrument-maker and the appliance stays, as the surgeon leaves it, which is an important consideration where treatment is desired for one of the ignorant classes. (2) The disadvantages of the solid jacket are that it is hot, unclean and

[1] Presented before the Medical and Chirurgical Faculty of Maryland, Dec. 15, 1905.

may be unsightly and clumsy. It may set up eczema and after a short time comparatively soften and then not fulfill the indications of treatment. When plaster jackets are slit up the front for the applications of lacing, which can be applied by a shoemaker, etc. they offer the disadvantage of being laid aside carelessly by the ignorant who cannot be made to realize the importance of constant support. A good jacket should be of a uniform thickness throughout and not too thick, as was pointed out in speaking of the plaster bandage. It should be well padded with piano felt over all bony points.

Upper Dorsal and Cervical Cases.

If the disease is above the seventh dorsal vertebra, it should be supplemented by some form of head support; perhaps the most convenient to use in



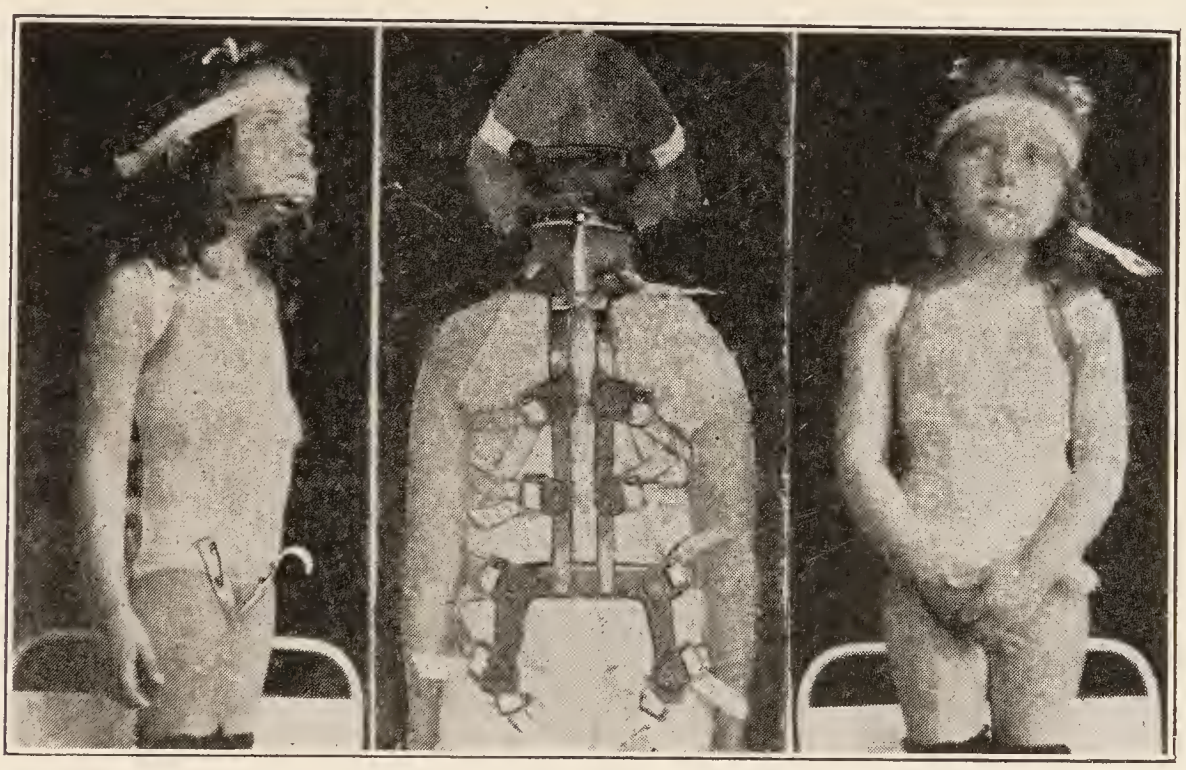
FIG. 155.—Jury mast and plaster jacket on a case with marked lateral deviation in upper dorsal region; (obsolete method).

conjunction with a plaster jacket, is the jury mast, which consists of an adjustable steel upright fastened to the middle of the back of the jacket by means of transverse pieces of tin, which can be incorporated in the jacket. The upright follows the contour of the spine and arches as a spring over the back and top of the head and to this can be attached a leather head-sling, by means of which more or less head traction and partial suspension may be gained. *This, however, is not to be recommended as a reliable method and should only be used as a makeshift* (Fig. 155).

A second method of removing the superincumbent weight in *cervical caries* is by what is known as the Thomas collar, which consists of a piece of pasteboard, cut out the desired shape to make a full, tall collar, which will rest in front on the sternum and laterally on the shoulders. This pasteboard is thickly and thoroughly padded with oakum, cotton or felt around which are wound ordinary gauze bandages. The patient is allowed to wear this and if it flattens down at all, additional padding can be added until it is of sufficient size to fully extend the neck and take the weight of the head off of the cervical part of the spine. Sometimes, for upper dorsal disease, a steel ring is incorporated in these collars, from which ring extends downward rods terminating in loops. Incorporated in the plaster jacket to be used in this connection are tapes and buckles, by means of which, through the loops, the rods can be forced upward, and thereby additional removal of the superincumbent weight of the head may be effected. *This is also a makeshift to be used until a more accurate steel brace is at hand.*

The Steel Back Brace.

One of the cleanest and most efficient spinal supports is to be found in a well fitting steel back brace and apron. This is known as the Taylor back brace,



A *B* *C*

FIG. 156.—C. F. Taylor's back brace.

A, Brace and head ring (side) with "apron;" *B*, brace and head ring (back); *C*, brace and head ring (front) with chin-piece open and showing the snug fitting apron.

having been devised and modified by Doctors Charles Fayette Taylor and Henry G. Davis, of New York. It is essential, however, that it shall fit as snugly to the skin on either side of the spinous processes from below up to the apex of the kyphos. Above this point it should not touch the back so that it will act as a lever. This back brace consists of two parallel uprights from three-eighth inch to one-half inch in width and thick enough and properly tempered to be rigid, which extend over the transverse processes from the fourth lumbar vertebra up to about the third dorsal. All along in the region of disease, projecting into the interval between the uprights one-eighth of an inch or more,

are fastened "steel pressure plates." The uprights are supported at the bottom by a rectangular, two pronged fork, or U-piece, as it is called, the prongs of which are intended to rest in the fossae, just posterior to the trochanters of the femora. At the top the uprights are joined by a transverse strip of steel. At the top the parallel uprights are bent to an angle of about 45°, as the two oblique pieces pass towards the anterior borders of the trapezius muscle (Figs. 156, 157 and 165). In front, an apron of twill-cotton is made, which is fitted snugly to the patient by means of gores. It extends from the top of the sternum to the symphysis pubis from above downward, and laterally to the mid-axillary lines. This apron is joined to the uprights and forks of the back brace by means of buckles on the latter and straps on the former. For this brace to be efficient, the straps should be kept tight all the time and be non-elastic. In disease above the seventh dorsal vertebra, a single upright should be prolonged from the upper transverse strip of steel on the upper part of this brace to a point on the back of the neck, which corresponds with the axis. At this point, a ring hinged at the ear is attached horizontally, which will encircle the neck and be sufficiently large to support the chin and occiput. It locks at the opposite ear. At the front and back, cups of sufficient size are made of gutta percha or metal to receive the chin and occiput. The single upright, which is projected from the brace, is adjustable by means of a set-screw to produce any degree of head support (Fig. 156). The ring is detachable by means of the hinge and lock at the sides and can be lifted off of the projecting upright. This arrangement is adaptable to cervical, as well as upper dorsal disease. It is sometimes well to have two steel occipital uprights with buckles for fastening a brow band, so that when the chin portion of ring is opened, as it is necessary to do for the patient to eat, the head will be still supported firmly (Fig. 156).

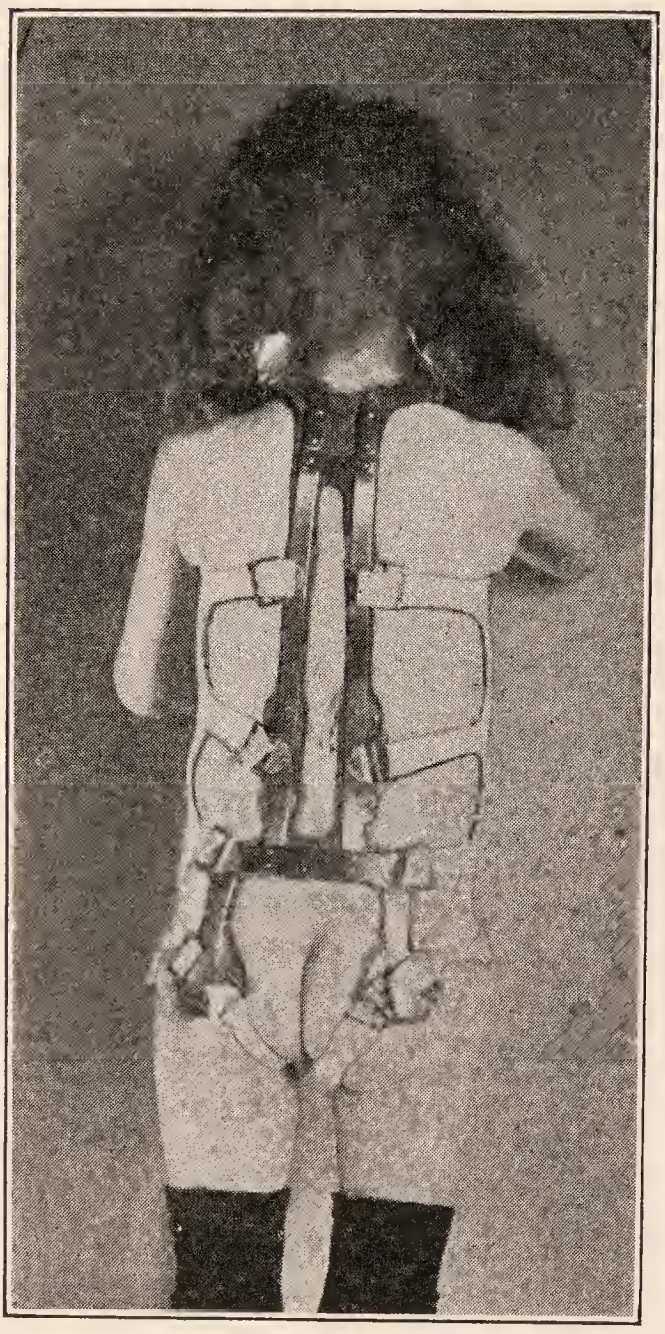


FIG. 157.—C. F. Taylor back brace with U-piece at pelvis. "Pressure plates" shown in lumbar region.

To Make a Plaster, Felt or Aluminum Shell.

The Dollinger brace, depicted in Hoffa's textbook, has been, so far as the writer knows, but little employed in this country except by Young. Briefly, it may be likened to a tortoise shell, in which the shell was projected upward or forward, so that the back of the head is also covered. This shell has been made of paper, plaster of paris bandages or felt over the back of a cast of the head, shoulders, back and pelvis of the individual suffering with upper dorsal or

cervical Pott's Disease. This shell was reinforced with steel, by the writer (Fig. 158). Riely makes the Dollinger brace of aluminum.

For several years the writer employed this device in the treatment of a large number of these cases and can confirm Young's observation, made in 1904, with regard to its value in the treatment of external pachymeningitis, so often a complication of Pott's Disease in this region.

My method of procedure differs from any description I have seen or read of and is as follows: The patient has been hyper-extended on the upright kyphotone, or placed on the Brackett hammock, or simply face down on a table, in each



FIG. 158.—Modified plaster of paris shell reinforced with steel and varnished.

case with the thighs at right angles to the trunk to lessen the lower dorsal and lumbar lordosis.

The position obtained by the table method has been found admirable and has been frequently adopted. A strip of stockinet is drawn smoothly over the head, neck, shoulders, and back (or preferably the skin and hair are smeared with vaseline) and semisolid plaster of paris is put on as rapidly as possible before setting; thus an accurate mold is obtained; or preferably dental wax may be softened in hot water, rolled out into a thin sheet with a bread roller and then molded smoothly over the back of head, neck and trunk. From this a duplicate cast of the patient is obtained in the usual manner by pouring plaster of paris into it.

The next step is most important and it is the correction of this cast. First, the shoulders are built upward and backward by additional wet plaster, so that they may be pulled on, in the patient, in these directions by the shell to be made over the corrected cast. The next step is to correct the kyphosis, and this is done by sawing transversely across the cast through the centre of the deformity and giving as much hyper-extension as one's judgment prompts that the patient will be able to stand and filling in the gap with wet plaster. So far as I know this step was first done by Riely (Fig. 163).

Now it is a well-known fact that as the kyphosis increases, there is similarly an increase in the lordosis above and below the deformity. Conversely by lessening the lordosis we should, pari passu, lessen the kyphosis. Just as we found hyper-extension so valuable in overcoming anatomical, pathological and mechanical flexion seen in Pott's Disease, which method engrossed us so much in 1894–1895, so of late I have in spinal work (both antero-posterior and lateral) directed my attention to the lordosis and forward tilt of the pelvis, and I feel the correction or lessening of the cervical and lumbar lordosis as important as the dorsal kyphosis.

So the next step is to correct in the cast the lordosis above and below the deformity by sawing a wedge out and mending with wet plaster so that the back is flattened. In the cervical region the object to be striven for is such a position of the head as would correspond with that assumed in endeavoring to make as many "double chins" as possible for thereby the cervical lordosis is lessened to the maximum degree by extreme flexion of the head.

We have observed in children wearing the Taylor back brace and head ring how at times they walk with a forward leaning from the hips which is both ugly and awkward, and to help correct this by this method we cut out the cast somewhat in the region of the gluteal muscles. The whole is then smoothed where rough, with draw-knife and sandpaper (Fig. 163, II).

We have now the fully corrected cast ready to make the shell over. It is to be noted that the whole trunk and neck are now longer by converting the curves into straight lines, which is what we aim for in traction with a head-sling. Such a shell is then made over the image of the patient (corrected) and fits admirably.

The objection to the plaster of paris, paper or felt shells is that they so soon soften, especially at the shoulders, and as the shoulder portion is one of the most essential parts, it is a serious objection. These shells take a great deal of care and time to make of felt and of a uniform thickness throughout of plaster of paris, so that they must necessarily be expensive, and if of short life, the parents of patients rebel, and are not satisfactory to the surgeon in obtaining reliable results. These shells and braces made of sheet aluminum prevent inspection to see the degree of pressure or fit at any given point and the latter cannot readily be adapted to growth in children (Fig. 158).

The R. T. Taylor Four-upright Back Brace for Cervical and Dorsal Pott's Disease.

In recent years the writer has found the troublesome *remodeling of the image* of the patient *unnecessary* and has designed a steel brace to support and

hyper-extend the spine which can be *fitted directly on the patient.* It extends from the occiput to a pelvic folds and also has *lateral uprights*, corresponding with the post-axillary lines continuing to the pelvic band, which are attached above to the shoulder piece and which in turn should reach to the centre of the infraspinatus fossae on each side. An occipital band should extend forward over the parietals to the anterior hair margin at the temple. The pelvic band

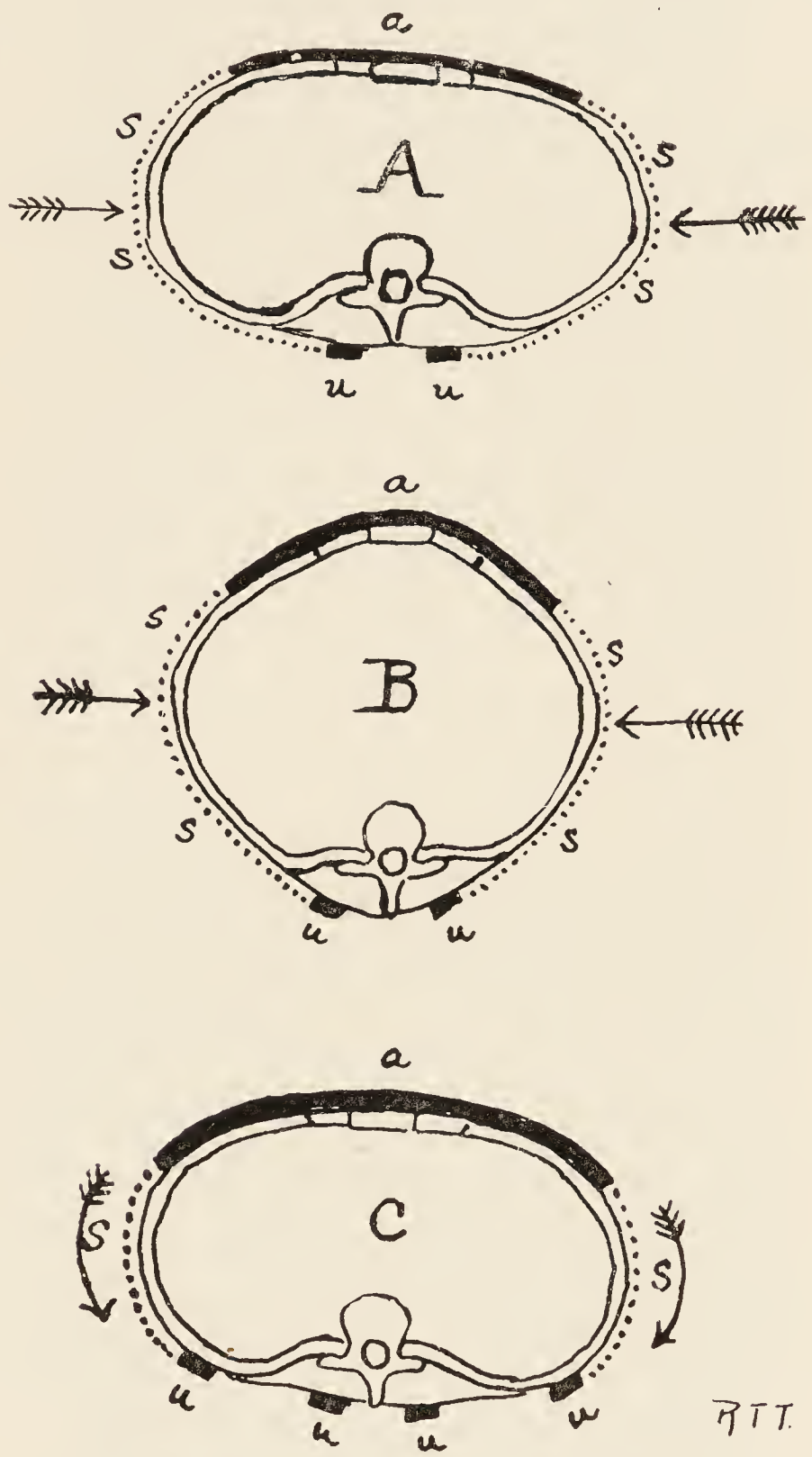


FIG. 159.—*A* and *B* show lateral compression and deforming of chest by long straps. *C* shows protection of chest from lateral compression by short straps from author's *added lateral uprights*. *a* = apron. *u* = uprights. *s* = straps. Arrows indicate force exerted.

of strap steel, 1½ to 2 inches wide, should be fitted across the back of the pelvis ¾ inch *below* the posterior superior spines and extend to within an inch of the anterior superior spines on each side (Figs. 161 and 164).

The central uprights are to extend from the pelvic band to the occipital band and be separated by a 1 to 1½ inch interval. In an adult these uprights and the lateral pieces are ⅛ of an inch thick by ¾ of an inch wide. For purposes of fitting, the central uprights can be permanently rivetted to the

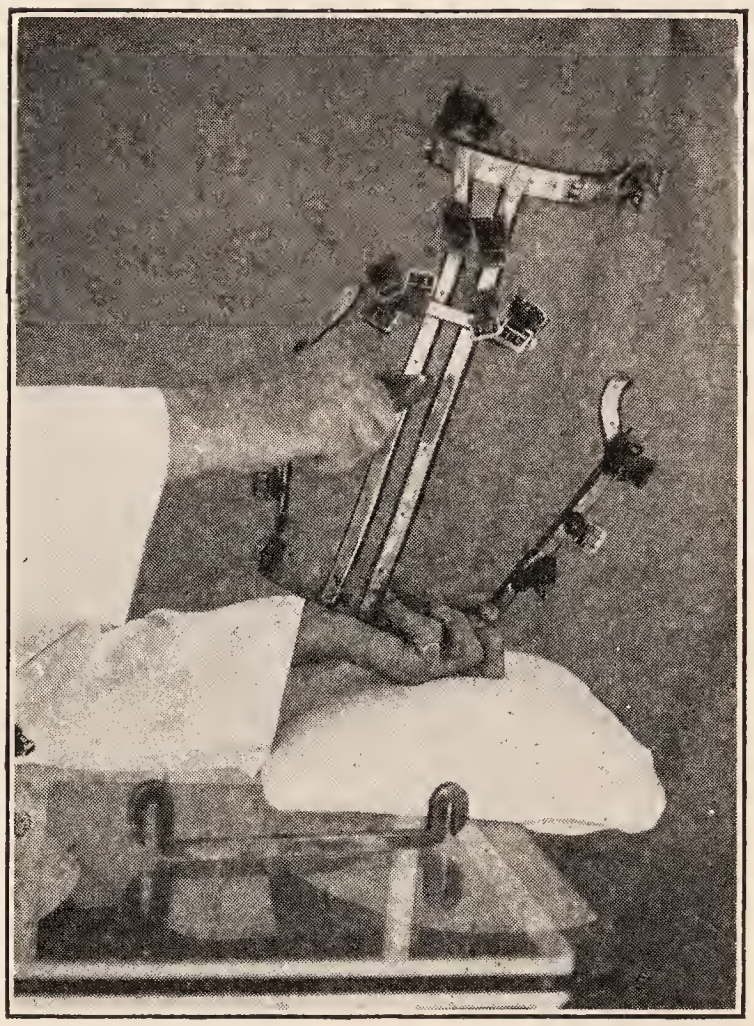


FIG. 160.—Method of bending and fitting central uprights with lateral uprights detached.



FIG. 161.—Author's brace applicable to cases of cervical, upper and mid-dorsal disease.

pelvic and occipital pieces and bent during the fitting to give the proper leverage or hyper-extension, when the patient is recumbent, so that pressure is made at the pelvis and kyphos chiefly. The lateral pieces near the upper end must be curved in, to come to the region of the lower scapula in order to be attached to the shoulder piece. Prior to fitting these are only to be attached to the pelvic piece or unattached. The occipital piece just over the mastoid has a stop-joint with set-screw, where it joins the parieto-temporal portion; this permits of adjustment of the temporal band and chin-sling (Figs. 160, 161 and 164).



FIG. 161A.—Author's brace used with webbing straps instead of apron to promote chest expansion.

The advantages of this steel brace are rigidity, durability and lightness. It gives support where it is most needed, not only over the transverse processes in the region of the disease, but over the ribs and shoulders. It is made in accordance with the therapeutic requirements from pathological findings and must fit. It is easily adjusted and one can see whether pressure and support are exerted in the proper places, which is impossible with the Dollinger or similar modified braces. For patients living at a distance who cannot return for brace adjustment this brace will be found very serviceable, for once fitted it is so rigid it is not likely to change its shape, as I have found is often the case with the

C. F. Taylor back brace or any two upright brace. Four uprights cannot produce lateral thoracic pressure as is the case in two upright braces (Figs. 159 and 164).



FIG. 162.—Goldthwait collar for cervical disease.

The Goldthwait collar is a very useful brace in many cases of cervical disease and consists of a cup for the chin and one for the occiput, supported on a ring, which is attached on either side of the neck by means of steel wire uprights,

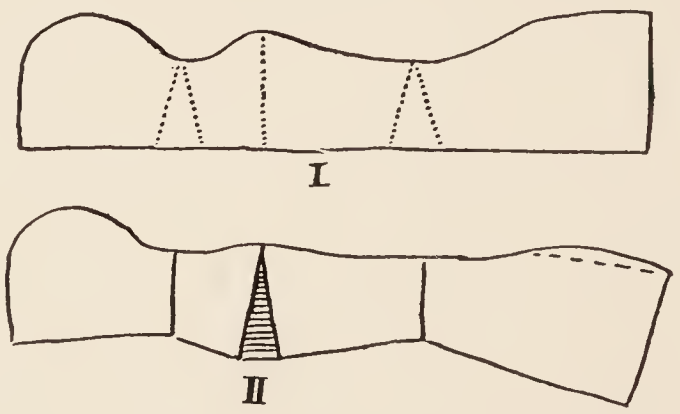


FIG. 163.—Showing author's method of correcting model.

which in turn are attached to a piece of steel, which passes from the bottom of the ribs on one side up over the shoulders around on the sternum, and up over the opposite shoulder down on the other side. A single webbing strap will

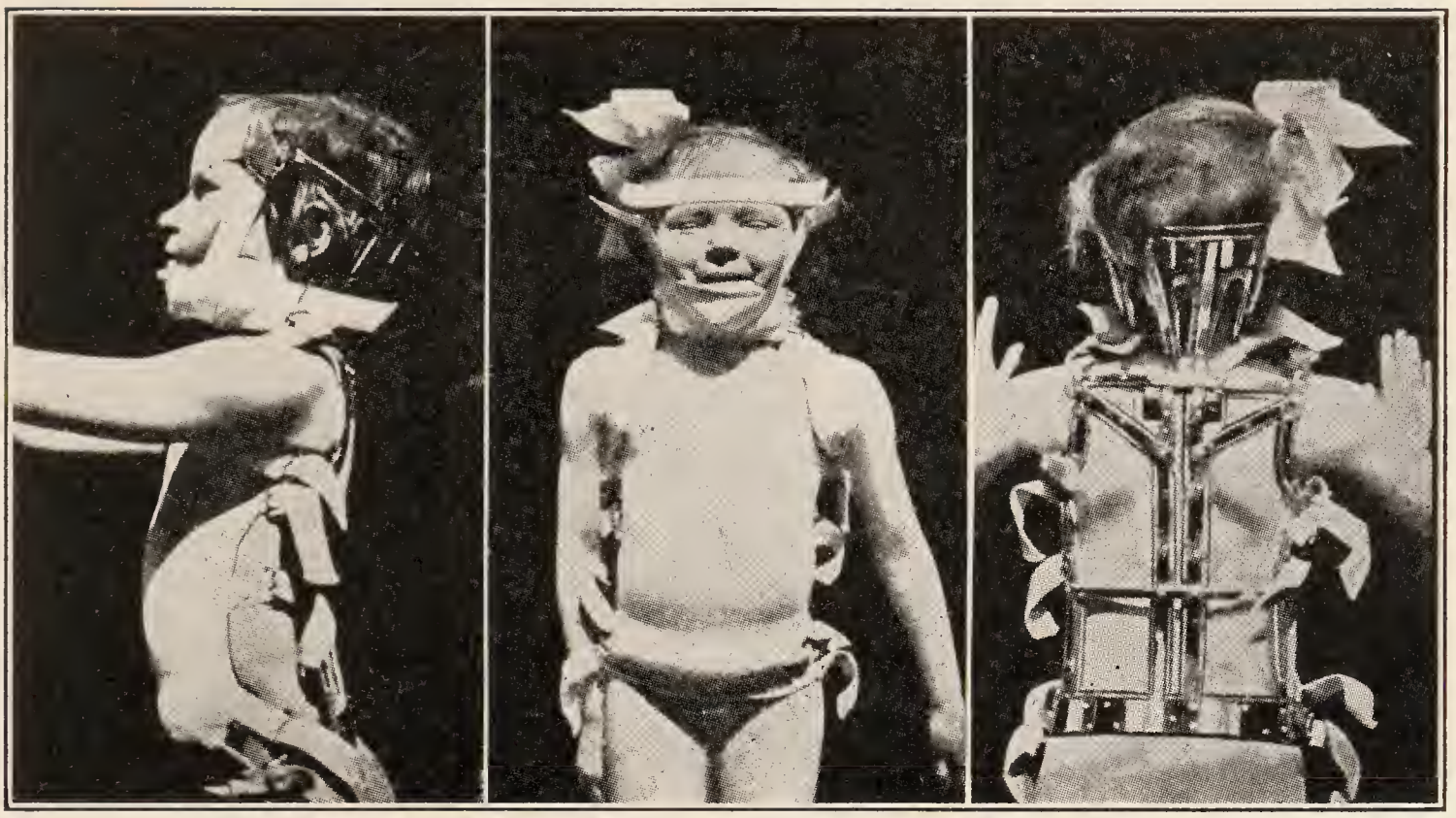


FIG. 164.—Author's brace.

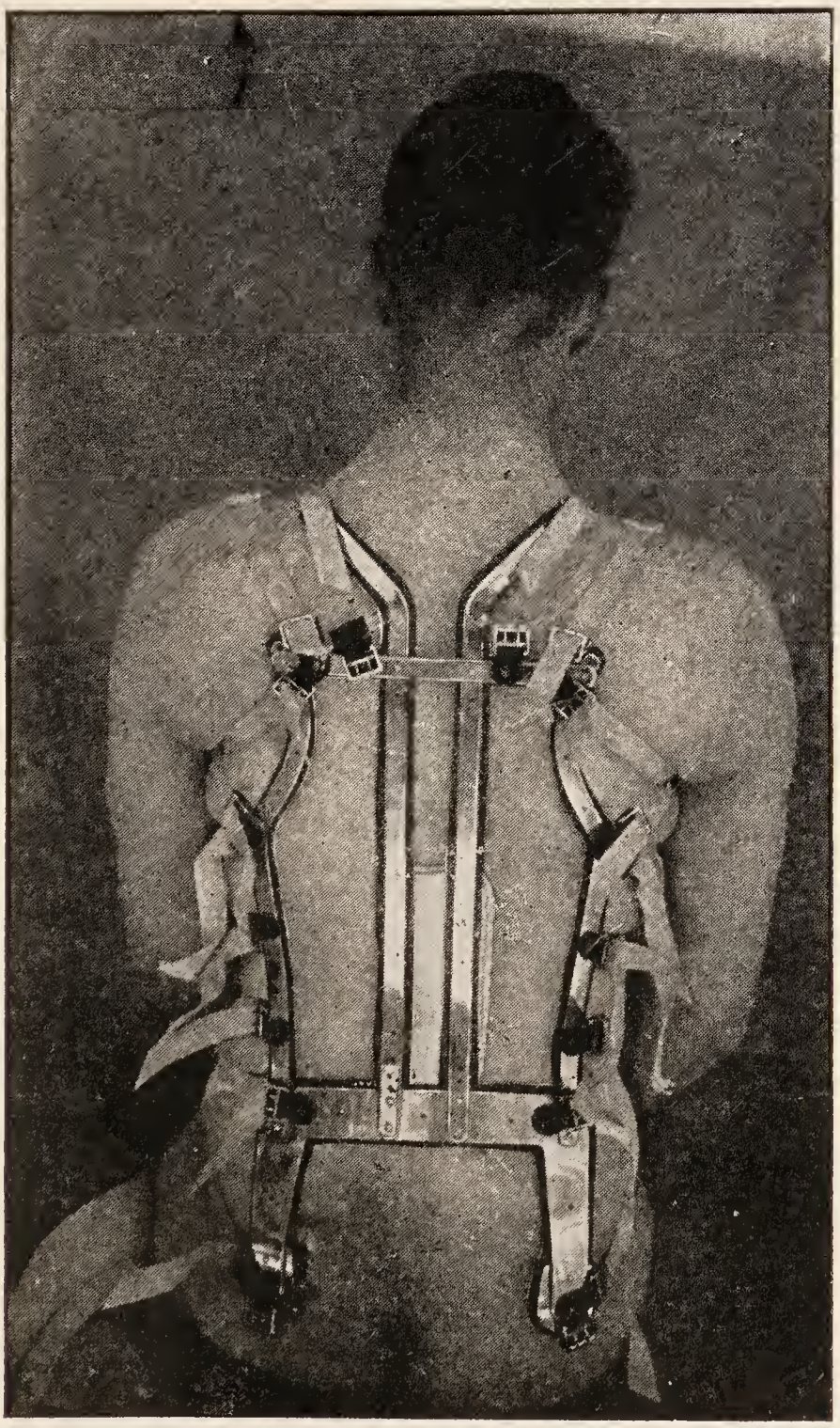


FIG. 165.—Lateral uprights added to C. F. Taylor brace for lumbo-dorsal disease. *U* = "U-Piece" to extend further down on pelvis and increase length of leverage.

hold these uprights in place in passing around the thorax. A hinge and lock are provided as in the C. F. Taylor head ring (Fig. 162) to open at back.

Appliances are faulty from (1) flexibility; (2) imperfect fixation from a badly fitting brace, loose or elastic straps. Axillary crutch supports attached to a steel waist band afford a variable and unreliable support, especially in children whose hips are not large and are ridiculous as supporting the shoulders and not the spine. They should not be bought having no scientific basis in Pott's Disease and are chiefly seen on braces designed by ignorant brace-makers.

Vaccines and the Opsonic Index.

Much interest was revived by the work of Sir Almroth Wright,[1] in an endeavor to get a definite index by clinical blood examination of the degree of immunity possessed by patients in various diseases. Results at measuring this degree of immunity or increased resistance had not been satisfactory with agglutinins and bacteriolysins, so that Wright suggested that there must be some substance in the serum which, when combined with the white corpuscles (polynuclear leucocytes or phagocytes) would show in varying conditions a varying degree of phagocytosis or power of ingesting the invading bacteria. He thus, in a way combined Metchnikoff's theory of phagocytosis with Ehrlich's "side chain" theory of the action of the serum. This substance in the serum he called opsonin, which means "to prepare a meal for." Further, he showed that this amount of opsonin could be increased or diminished by the hypodermic injection in definite doses of emulsions or "vaccines" of the infecting bacteria destroyed by heat. The comparison of the action of the serum of the patient with the serum or a "pool" of the sera of several normal persons, he called the "opsonic index."

For example, if 100 phagocytes combined with the normal serum ate on an average six bacteria each, which he would call normal or one, and the same number of phagocytes of the patient gave only an average of four, he would compute the opsonic index of that patient by the proportion $6 : 1 :: 4 : x$ or x would equal 0.66 in this particular example. If the index was subnormal, the power of resistance or degree of immunity was called low and if above normal, high.

In an infected individual, however, this index is variable and may possibly be low one day, high the next and on the normal line the third day, so this variability must be taken into consideration in an infected individual, even without artificial vaccination, and is a valuable point in diagnosis. Possibly an autovaccination, as Wright pointed out, may or may not take place from the seat of the infection by massage or movement and cause this over- or under-stimulation in opsonic production in the patient.

We know clinically by laboratory examinations on this point that too large dosage of vaccine, or vaccinations given at too frequent intervals, will lower the opsonic index, and moderate and proper doses will raise it. In other words we cannot unduly push this production of the opsonic substance in the patient's serum.

[1] Proceedings of the Royal Society, Oct. 31, 1903, No. 72; Mar. 7, 1904, No. 73; Sept. 28, 1904, and Jan., 1905, No. 74. Bulloch, Practitioner, Dec. 1905, and Lancet, 1905, vol. ii, page 1605. Wright, Roy. Soc. Proc., 1902, vol. lxxi. Lancet, July 5, 1902. Leishman, British Med. Jour., Jan. 11, 1902.

Briefly, Wrights technique[1] as pursued by Doctor E. A. Knorr and the writer in our observations is as follows:

1. A small tube is used to collect 15 to 20 drops of the patient's blood from the finger or ear and a similar tube to collect blood from a normal individual or individuals. These tubes are put in a water or electric centrifugal machine, until all the corpuscles are driven down, leaving the clear supernatant *serum* above.

2. **Blood** is drawn from the finger or ear of a normal individual into a small test tube containing an aqueous solution of 1 per cent. sodium chloride and 1.5 per cent. sodium citrate (or .1 per cent. ammonium oxalate) to prevent clotting until the solution is a bright red, then centrifugalized. Pipette off the solution above the corpuscles which have been thrown down. Fill the test tube with 1.5 per cent. sodium chloride solution, shake well to wash corpuscles free of serum and again centrifugalize and pipette off the supernatant fluid. This leaves the lighter white corpuscles as the "cream" on top of the red corpuscles.

3. **A bacterial emulsion** must be prepared to mix with the serum and white corpuscles. In the case of the tubercle bacillus, take a small quantity, about the size of a grain of rice, of the dried preferably fatty or sterile tubercle bacillus powder of Von Rook, Burroughs, Wellcome and Company or Trudeau and mix it in a smooth agate mortar with a few drops of .1 per cent. salt solution, adding drop by drop additional salt solution, until a uniform solution like very thin milk is obtained. Centrifugalize this and retain all the supernatant fluid as the "tubercular emulsion," the clumps to which the tubercle bacillus is prone having been thrown down.

The staphylococcus or similar emulsion is made by taking a oese full of a 24 hour agar culture mixing it with 5 cc. of sterile salt solution and then centrifugalizing and retaining the supernatant fluid containing them, as the staphylococcus, etc., emulsion.

The next step is to mix these with the sera and corpuscles. First, long capillary pipettes are drawn out in the Bunsen burner and a teat is put on the large end. With a glass marking pencil an inch or two is marked off on the capillary end and the *normal serum* is drawn up to this mark, then a bubble is allowed to enter and the same quantity of the bacterial emulsion is drawn in. Finally another bubble is admitted and from the "cream of the corpuscles" the same quantity is drawn in of the leucocytes.

These three are then squirted out on a glass slide or watch crystal, thoroughly mixed, drawn into the capillary, squirted out again and mixed and again drawn in some distance into the capillary, which is then sealed in the flame of the Bunsen Burner, the teat taken off and the pipette labeled with the glass marking pencil. The same procedure is then gone through with all the *sera from* the *patients*.

If more than one bacterium is under investigation a normal or pool or control mixture must be made of the normal serum, bacterial emulsion and leucocytes *in each case* as the tubercle control would not do for determining a coccus opsonic index, it goes without saying and vice versa.

These labeled pipettes are then put flat in the thermostat for 15 minutes at 37°C., when the closed end is broken, the teat is put on again and the mixture

[1] Simon's modification.

squirted on one end of a slide; with the end of another slide the smear is made and it is air dried.

In the case of cocci the slide is fixed by very gentle warming over the Bunsen burner, testing frequently with the hand that it be not over heated and this method is preferable to alcohol hardening as the cocci are shriveled thereby. Very frequently, if thoroughly air dried, fixation by heat is unnecessary.[1] It is then stained with 1 per cent. aqueous solution of methylene blue.

With tubercle bacilli fix the air dried slide in a saturated solution of bichloride of mercury two minutes, wash, stain with carbofuchsin, boil gently over flame, being careful the slide is always covered with the staining solution and no drying or precipitation occurs, which can be accomplished by means of a pipette end and not overheating. Decolorize rapidly in 2 per cent. solution of sulphuric acid, wash and neutralize the acid in a .1 per cent. carbonate of soda solution, wash and counter stain with 1 per cent. aqueous solution of methylene blue, and wash thoroughly.

When air dried the slide is ready to count. This we did with a mechanical stage and counted in nearly all instances 200 polynuclear leucocytes. We used two indexes, Wright's, which requires counting the individual bacteria ingested in each leucocyte and Simon's, which calls for the percentage number of phagocyting leucocytes and is accurate, perhaps more so than Wright's, if the bacteria tend to clump and is much easier on the eyes. Both indices show identical variations but Wright's, if very high, shows a much higher curve than Simon's, which is not open to the error introduced by the ingestion of clumps of bacteria notably the tubercle bacilli which seriously affect Wright's index. In many instances we made both counts.[2]

The following is a characteristic chart of an acute tubercular osteitis of the cervical vertebrae with proper vaccination and excessive vaccination. No temperature reaction nor reactionary symptoms of any kind appeared, but the opsonic index told us when we were reaching the danger point. The patient was in bed with head traction and the symptoms seemed to abate perhaps more rapidly with the vaccination.

Koch's tuberculin T. R. was employed in beginning doses of $\frac{1}{5000}$ mgm. and increased to $\frac{1}{100}$ mgm. (Figs. 166A and B).

It will be seen in Chart A that a hypodermic dose of $\frac{1}{5000}$ of a mgm. of Tuberculin T. R. repeated at five to seven days interval increased the resistance to the tubercle bacillus, whereas a dose of $\frac{1}{200}$ of a mgm. caused a falling opsonic index.

After the study of a large number of opsonic charts we concluded in Bone Tuberculosis, it is safer to give as a routine in children $\frac{1}{1000}$ *of a mgm. of Tuberculin T. R. once a week to help immunity*, to supplement that poured out constantly from the focus of disease. Large hypodermic doses must do prolonged harm. The increasing dose with a view to establishing tolerance is risky.

A characteristic secondarily infected case of lumbar Pott's Disease, cultures from sinuses showing staphylococcus, gave the following chart after vaccination

[1] Knorr.

[2] Simon, Lamar and Bispham, Jour. Exp. Med., Dec. 21, 1906.

with very appreciable lessening of the discharge, which had continued for months with hectic fever, which also abated. The one billion staphylococcus vaccine is prepared by adding 10 cc. of 1.5 per cent. salt solution (sterile) to a 24 hour smear agar culture of the aureus, thoroughly oscillating, then pouring on a second similar tube and so on until four tubes have the cocci thus washed off. Freshly drawn blood in a pipette is mixed with an equal quantity of this suspen-

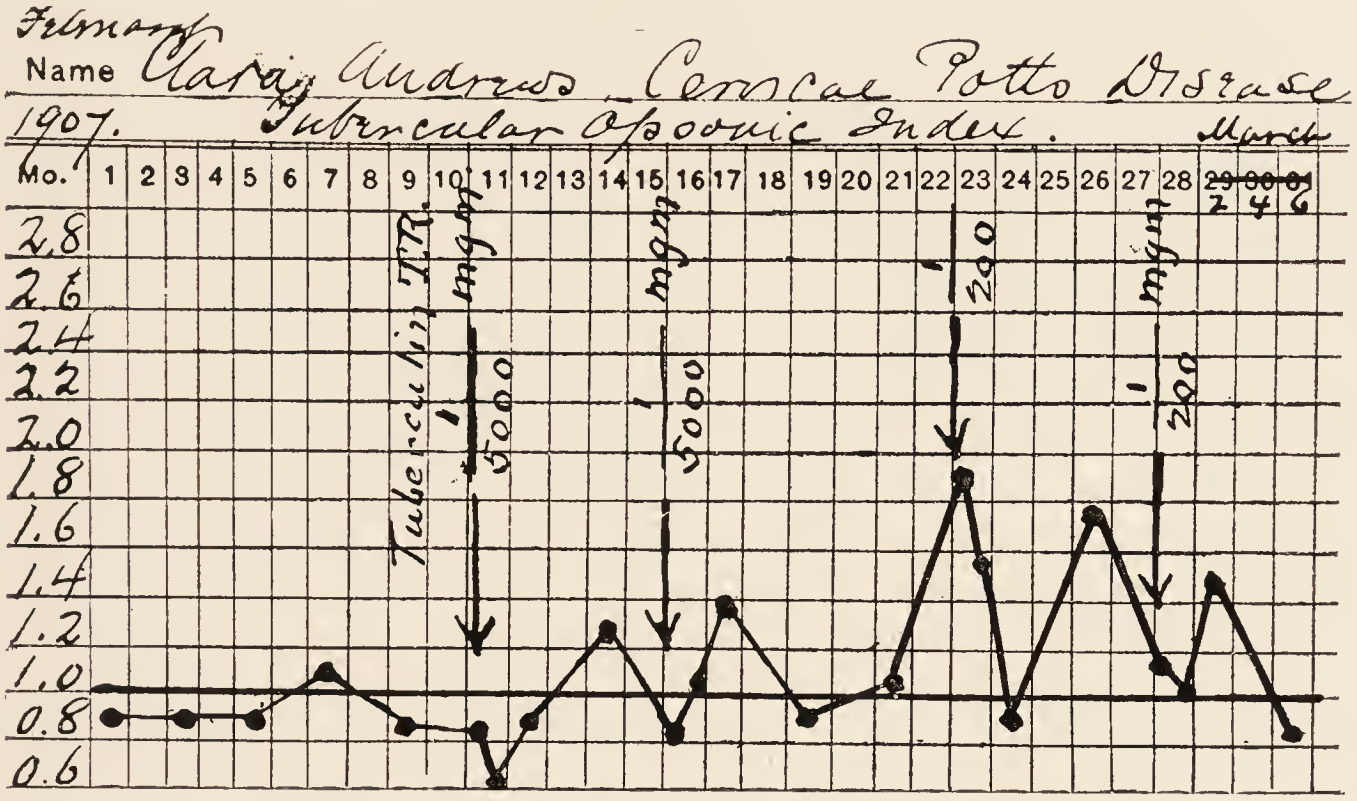


Chart *A*.

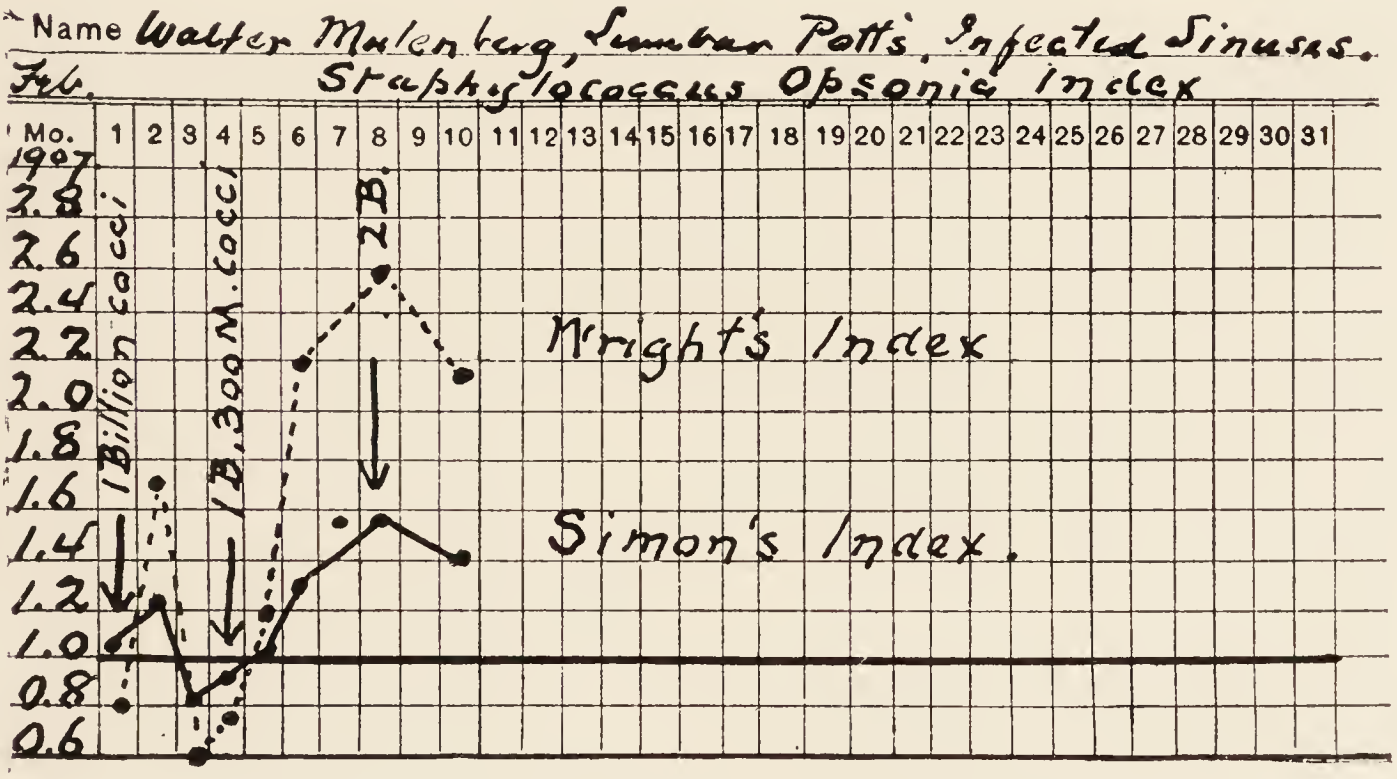


Chart *B*.

Fig. 166.—Chart *A*, Tubercular opsonic indices. Arrows indicate vaccinations. Chart *B*, staphylococcus opsonic indices.

sion and a count made in comparison with the red cells on a slide. Thus we can determine in a given volume how many cocci we have. The vaccine is then boiled in a sterile tube for 30 minutes and 0.25 per cent. lysol added as a preservative. It is then incubated 24 hours and cultures made to be sure it is sterile.

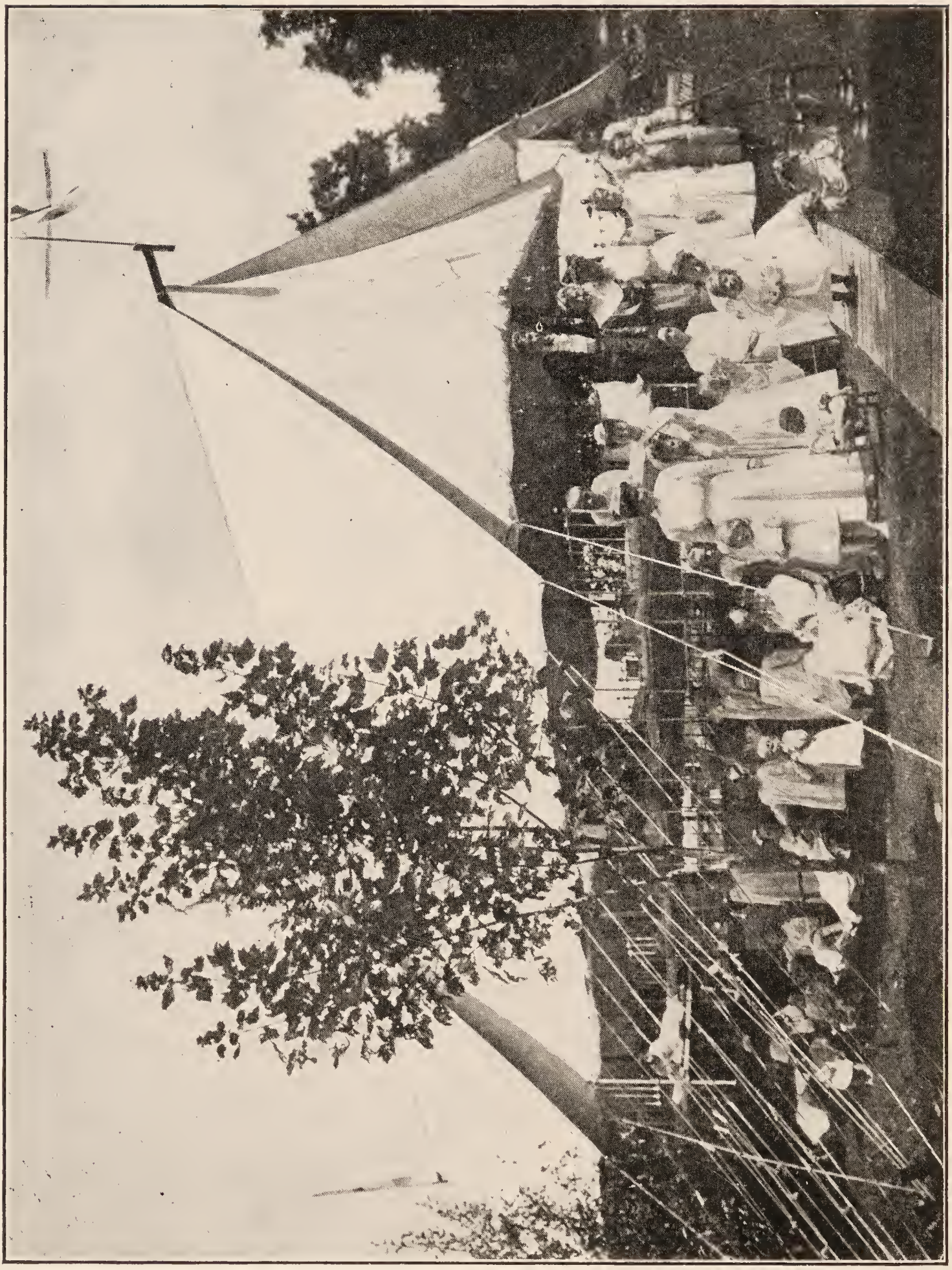


FIG. 167.—Tent ward at the Mountain Hospital, Blue Ridge Summit, Pa.

One billion cocci injected showed a "positive phase" or increased power of resistance or increased ingestion of cocci by phagocytes, followed the next two days by a "negative phase" of decreased power of resistance. Then a vaccination with one billion three hundred million cocci showed a fairly progressive positive phase until a third vaccination on February 8th of two billion produced a negative phase or falling index, which should warn the clinician he is either giving too large a dose of vaccine or at too frequent an interval.

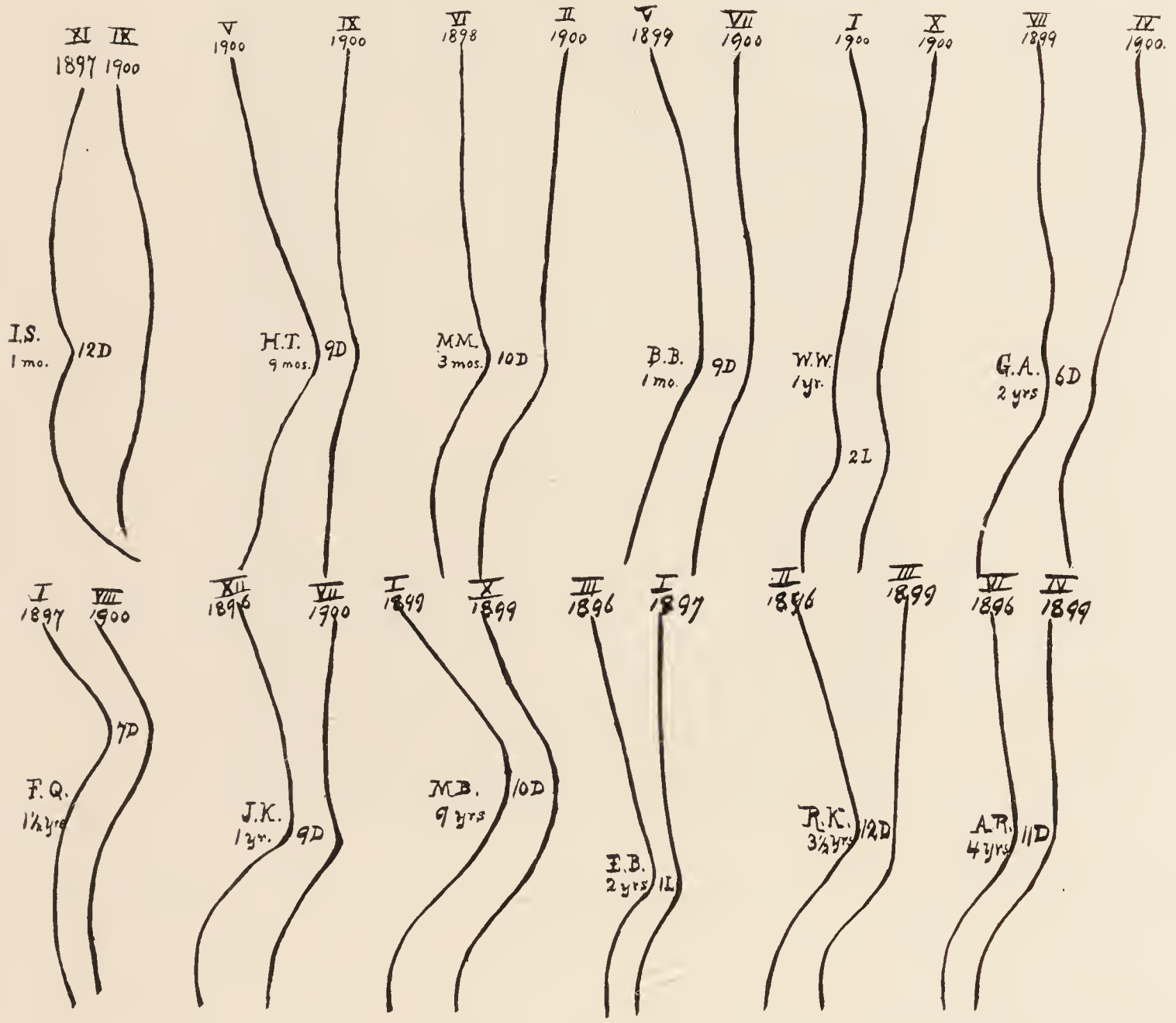


FIG. 168.—The duration of the disease when first seen is indicated on the left of the deformity lines. Tracings of some lower dorsal and lumbar cases of Pott's disease, showing results of treatment, by plaster of paris jackets.

We were thus able to confirm in these and many other charts, Wright's observation, that in infected cases, we have a high, low and variable index for that organism.

The opsonic index seems a most valuable guide as to proper dosage of vaccines, which we cannot observe, otherwise clinically finely, unless we give so much a temperature reaction is produced, which is to be avoided, as detrimental, of course.

Hypodermic diagnostic tests which produce temperature, local and focal reaction with redness, pain and muscle spasm when viewed from the Opsonic Index readings may be regarded as an overwhelming set back to the toxin tolerance. Therefore the skin or intradermic test is to be preferred.

In normal serum the opsonic power is destroyed by heating to 60°C. for 10 minutes, and this does not occur in diseased conditions and the serum is called "immune serum," so that phagocytosis occurs almost as readily after heating as before, which is not the case (i.e., phagocytosis) with heated normal serum. This is a possible means of diagnosis.



FIG. 169.—A "Grand" Calot jacket for cervico-dorsal Pott's disease put on by bandage-head-sling suspension (Sayre Method) which is incorporated in the cast. Note the cast does not come to pelvis.

Operative Treatment of Pott's Disease.

Much has been written of late years pro and con in regard to the valuable addition to our means of combating the deformity incident to Pott's Disease and arresting the disease when aided by the methods previously described and those that will follow.

These operative procedures aim to produce ankylosis between the spinous processes or between the laminae or both, which have sound therapeutical and pathological reasoning to rest upon. If, however, the patient has little or no power of resistance to the inroads of Tuberculosis and rational mechanical methods are not employed as aids, even these brilliant operative procedures must fail.

In the writer's judgment it is unfair to expect them to cure a large and increasing kyphosis from a mechanical standpoint, just as it is unfair to expect a cure from these procedures of a paralysis due to an external pachymeningitis on the anterior surface of the cord from a pathological standpoint. Therefore these

operations should preferably be undertaken early in the disease before serious deformity has had a chance to occur.

The able authors of the chief procedures for producing ankylosis of the spine, which have widest acceptation are Doctor Frederick H. Albee and Doctor Russell A. Hibbs, both of New York.

Doctor Albee aims by an autogenous bone-graft, extending well above and below the area of disease, fitted into a split in the spinous processes, to produce ankylosis between the spinous processes.

Doctor Hibbs' operation scarifies adjacent borders of the laminae by stripping up their surfaces by a special small curved chisel and snipping off the spinous processes, partially detaching each one and replacing it, so that the base of one will rest on the denuded bone of two laminae from which they have been cut.

The success of the Albee operation depends on (1) the bone-graft taking, (2) the graft persisting and not being absorbed and (3) the graft growing in size and strength sufficient to permanently ankylose the spinous processes involved.

The success of the Hibbs' operation is vitiated, just as in scarification of a joint to produce arthrodesis, if perfect repair takes place instead of ankylosis. Thus adequate cutting into the adjacent borders of the laminae is essential. If at the same time spiculae of bone or osteophites grow into the spinal canal, these will produce intense pain on the sensory side of the cord, if the scarification is carried too deep.

The Albee Operation.—F. H. Albee in his textbook ("Orthopaedic and Reconstruction Surgery," W. B. Saunders Company, 1919 pages 100 to 119)

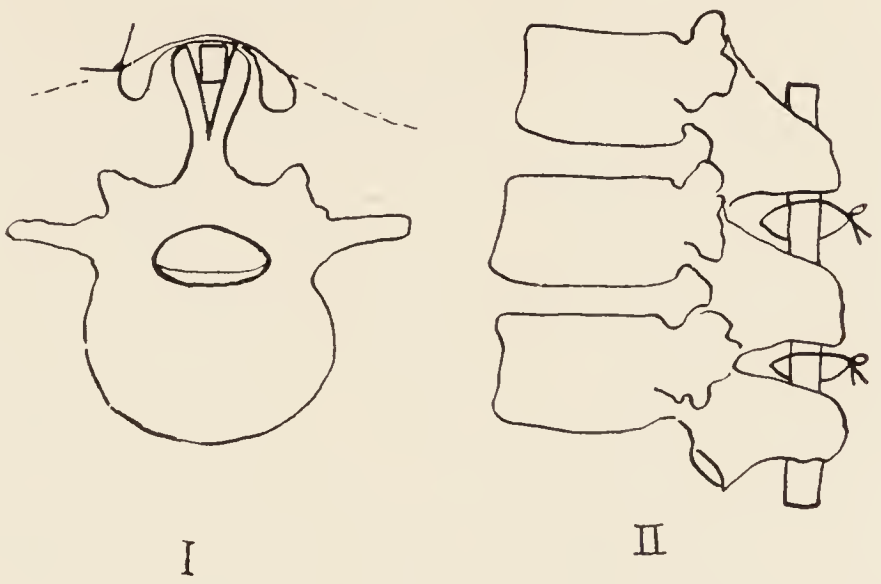


FIG. 170.—I. Superior view of the split spinous process and graft. Albee operation. II. Lateral view of three vertebrae and graft.

has suggested that a semi-lunar incision six to eight inches long be made to one side of the spinous processes, so that it will extend to the first or second vertebra above the lesion. After this skin flap is dissected back and the hemorrhage is controlled with hot saline compresses, the supraspinous ligament is split into halves longitudinally over the tips of the spinous processes with a scalpel and the interspinous ligaments are similarly cut. The lateral muscles and ligaments are not disturbed. With a wide thin osteotome (one inch) the spinous processes

are now split and fractured toward one side. These spinous processes must include two above and below the site of disease (Fig. 171).

When this gutter is prepared, a probe is bent to follow this curve and so determine the length of graft needed. The graft is obtained from the tibia, usually on the side next to the surgeon. In certain instances it is necessary to obtain a curved graft on account of a large deformity and this is best done by what Albee calls the "bent-shingle" technique, whereby the entire surface of the graft, that is, the side of the endosteum is cut transversely with an electric saw devised by Albee about half way through its thickness, so that the graft can be bent without fracture. Sometimes this graft is obtained by means of a

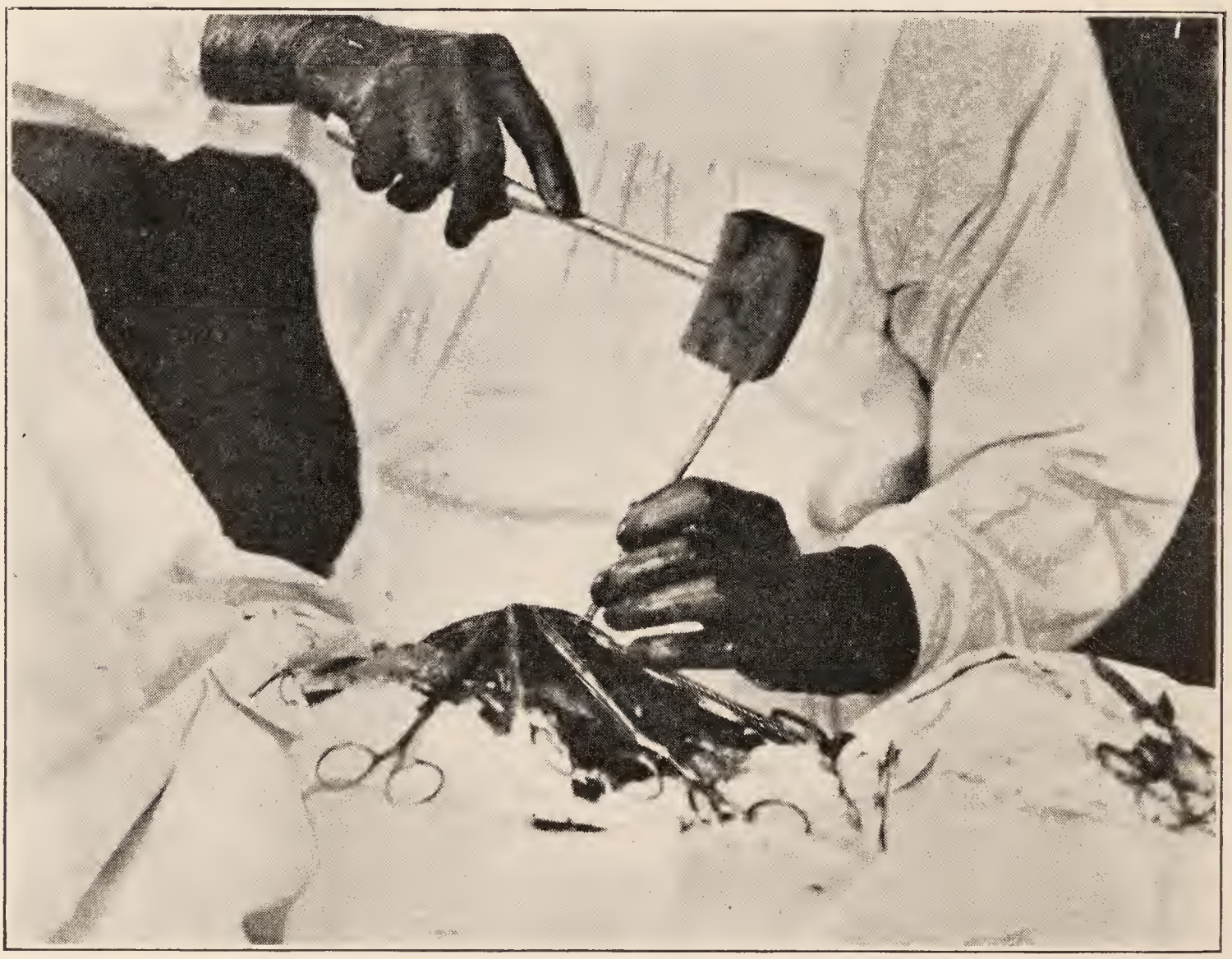


FIG. 171.—Splitting the spinous processes with osteotome.

twin saw and at others by the single saw. A very small osteotome is used to pry it out and it is grasped with forceps to transfer it to the gutter in the spinous processes. Different conditions require obtaining the graft from different portion of the tibia, but the reader is referred to Albee's textbook, for these technical details. After the graft is placed in the gutter and the knuckle is flattened by lateral pressure on each side as much as possible, it is sutured in position with kangaroo tendon, the needle being entered in the muscle and ligamentous tissues on one side, passed over the graft and into the muscle and ligamentous tissue on the opposite side and then tied over the graft. This holds the graft firmly down in position and brings the edges of the supraspinous ligaments and fascia together over it. These sutures are inserted, upward and

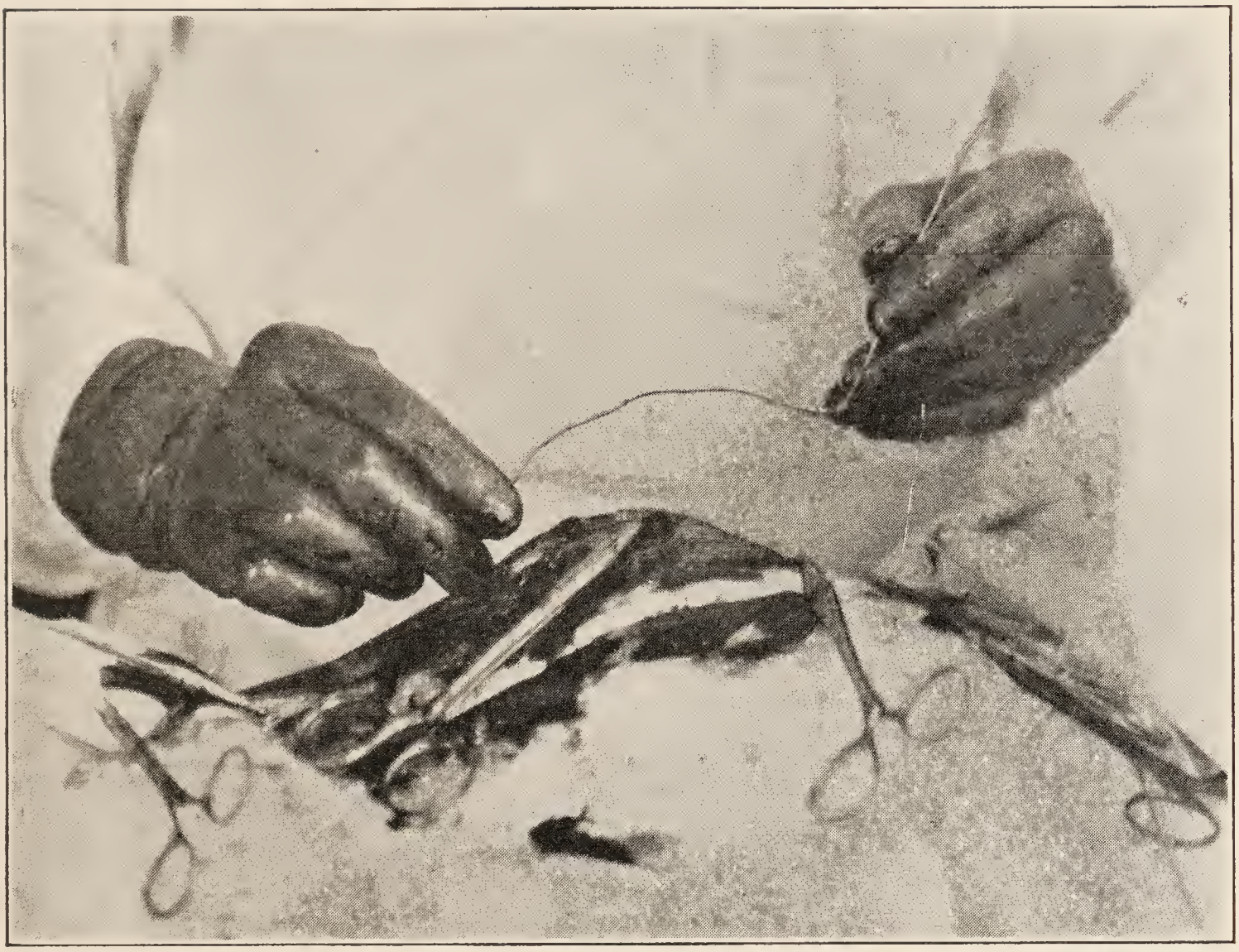


FIG. 172.—Getting the length and curve of bone-graft required with probe.

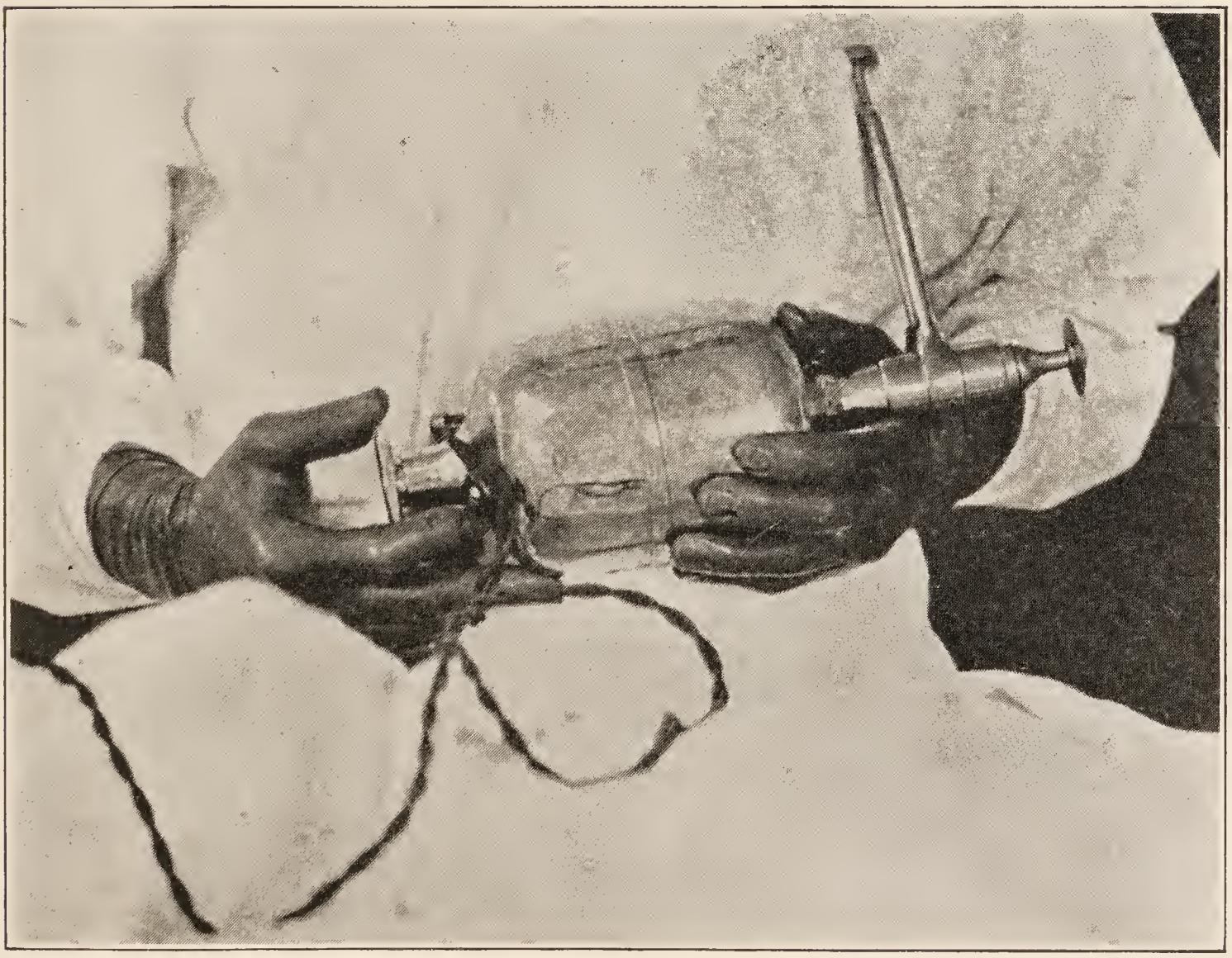


FIG. 173.—Albee saw.



FIG. 174.—Sawing the tibial graft. Salt solution dropped from syringe by assistant.

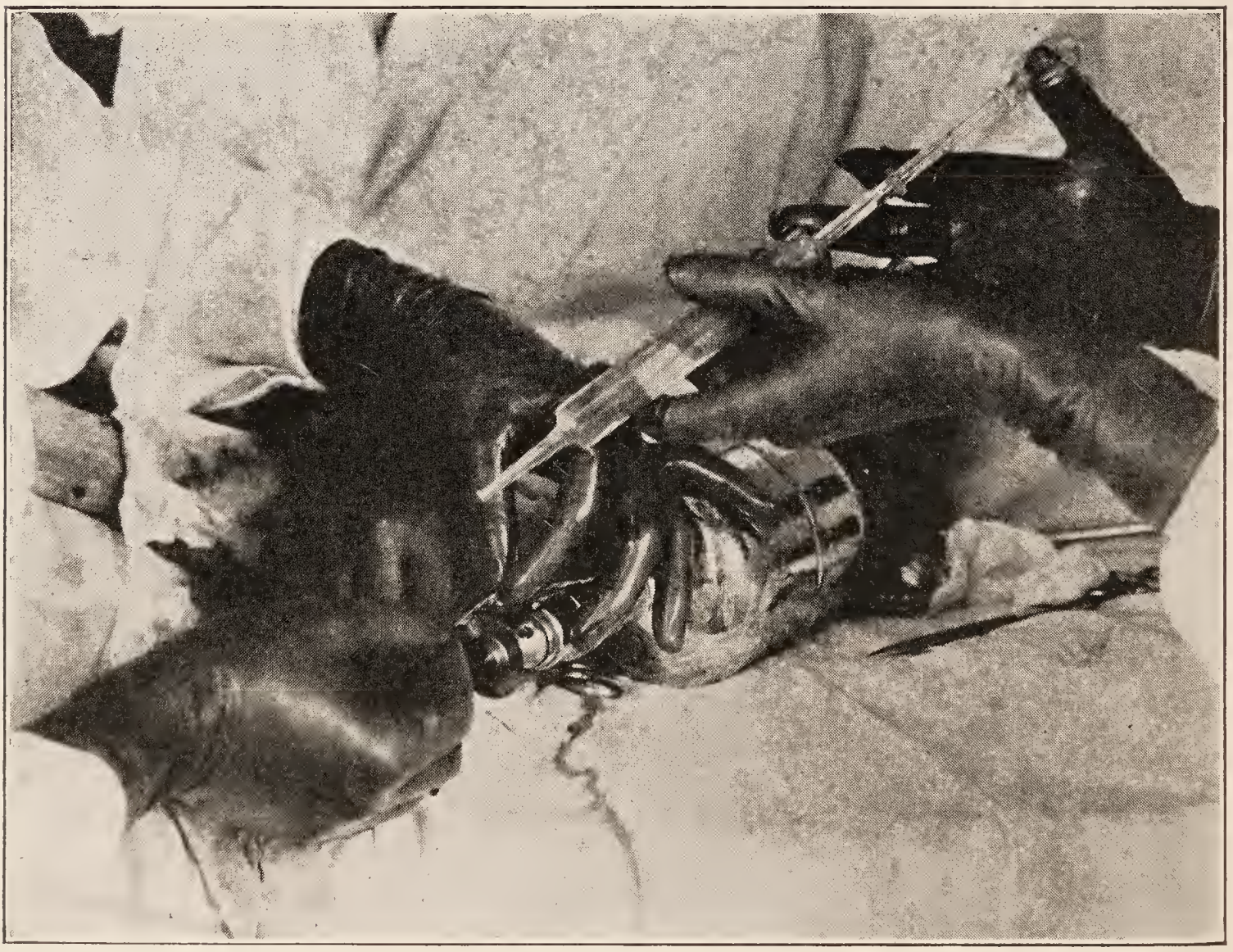


FIG. 175.—"Bent Shingle" technique, under cutting graft to facilitate bending it.

downward, until the whole graft is covered over. They are preferably placed in the interspinous spaces. Fixation, in bed or by plaster jackets or light spinal braces applied after both of these operations, with the patient recumbent is necessary for at least six weeks (Figs. 170 to 176).

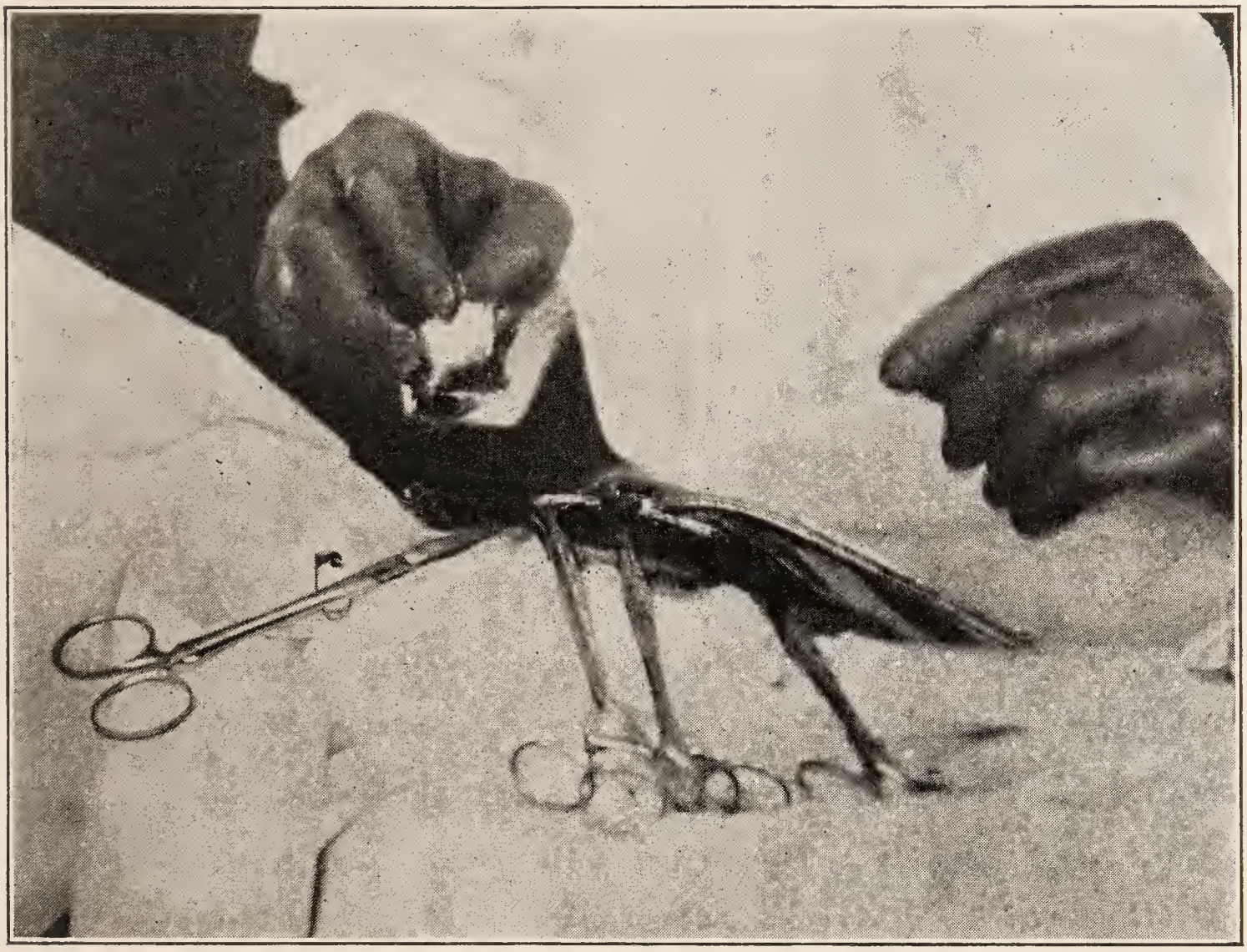


FIG. 176.—Graft sutured in the centre only.

The Hibbs Operation.—Hibbs' operation differs from Albee's[1] in that a longitudinal incision is made directly over the spinous processes through the skin, supraspinous ligaments and periosteum to the tips of the spinous processes. The periosteum is split over the upper and lower portions of the spinous processes and the laminae and stripped back from them to the base of the transverse processes. The spinous processes are then transposed after partial fracture, so that they make contact with fresh bone, the base of each partially with its own base and with the base of the one next below. The adjacent edges of the laminae being absolutely free from periosteum, a small piece of bone is elevated from the edge of the laminae and placed across the space between them, its free end in contact with the bare bone of the laminae next below it. The lateral walls of the periosteum and the split supraspinous ligaments are drawn together over these processes by interrupted chromic cat-gut sutures. The skin wound is closed by silk and a steel brace applied with the interval between the uprights increased somewhat at the site of the wound, so as not to make pressure upon it. Hibbs advises that rest in bed be absolute from 8 to 10 weeks, during the next four weeks sitting up be permitted and at the end of the twelfth week, walking.

[1] Jour. Amer. Med. Assoc., Aug. 10, 1912, vol. lix, No. 6, pages 433–435.

Treatment of Complication.

I. **Treatment of Cold Abscess.**—(1) Expectant treatment often yields good results and as long as the general health keeps good, or does not suffer, the abscesses should not be opened unless pressure symptoms are manifest, such as interference with any of the respiratory or digestive functions, pressure on the bowels or blood-vessels, or on a nerve or seem in danger of secondary infection through the skin and the blood examination gives a high leucocyte count. If the skin becomes very thin over such an abscess, so as to be nothing more than what we might term a paper covering, the abscess may be opened to save the bedclothes, as it is practically impossible to get at the seat of the disease, and remove all the tuberculous material and focus which is producing the contents of the abscess. If early incision is done, after evacuation of the pus, immediate subcuticular suture should be put in, as they are most prone to infection by the pyogenic cocci, when the patient will give evidence of, "hectic fever." If secondarily infected, the patient will probably have a discharging sinus which will continue as long as the disease is active, and may interfere with the application of a proper support. It should be borne in mind that these are "cold abscesses" and simply consist of broken down bone and caseous material. As a rule, they are surrounded by a thick, fibrous wall of granulation tissue, so that absorption must, of a necessity, take place very slowly, and the general health will suffer therefrom proportionately very little. An abscess may be the size of a large orange or even bigger, and yet it is better to leave it alone unless some dangerous symptom appears. If opened simple incision and evacuation yields better results than when extensive curetting is employed—as is done in acute abscesses. Subcutaneous silver wire sutures should be put in at once and the edges approximated immediately after evacuation in an endeavor to obtain primary union. Many large abscesses are entirely absorbed, without opening.

2. Frequent aspiration, with the idea of promoting absorption, is of questionable value, as many of the products of the abscess cannot be withdrawn through an aspirating needle of small or medium size or a trocar.

3. The injection of fluids or antiseptics to promote absorption or resolution has not been very satisfactory; however, where a sinus exists, it should be injected thoroughly and washed out occasionally with peroxide of hydrogen, and after this injected with a 10 per cent. solution of iodoform in olive oil, or better, as we have found, with 2½ per cent. solution of the 40 per cent. formalin stock solution. If there is no secondary infection, sterile water or 50 per cent. alcohol or decinormal salt solution or *dry mopping* out with gauze is preferable.

Following the suggestion presented by Taylor and Gallie of the value of "Tidal Irrigation" with hypertonic salt solution in cases of Acute Osteomyelitis,[1] the writer applied it to Tuberculous Sinuses with most gratifying results, in some instances cases that had multiple sinuses discharging for years healed in a few months. The principle involved is the alternate dilation of every nook and corner in the branching sinuses with the warm healing and cleansing fluid followed by a more prolonged suction upon the whole tract. It might be termed a hydraulic Bier active and passive hyperaemia. The Taylor-Gallie apparatus consists of an irrigating stand and bottle for the Hypertonic Salt

[1] Jour. Amer. Med. Assoc., 1920, vol. lxxiv, pages 1700 to 1706.

Solution connecting with a rubber tube and stop-cock. This tube passes to a specially designed rubber and metal cap, bellows-like, which fits over the sinus or wound. When fluid is allowed to flow under pressure, its weight on the edges of the cap, aided by a retaining bandage prevents the fluid from escaping and dilates the sinuses. This the authors speak of as "Positive Pressure." A second tube with stop-cock leads from the cap to a water valve, so that when the upper tube is closed and the lower tube is opened the cap adheres to the skin like a sucker and a vacuum or "negative pressure" is produced in the sinus

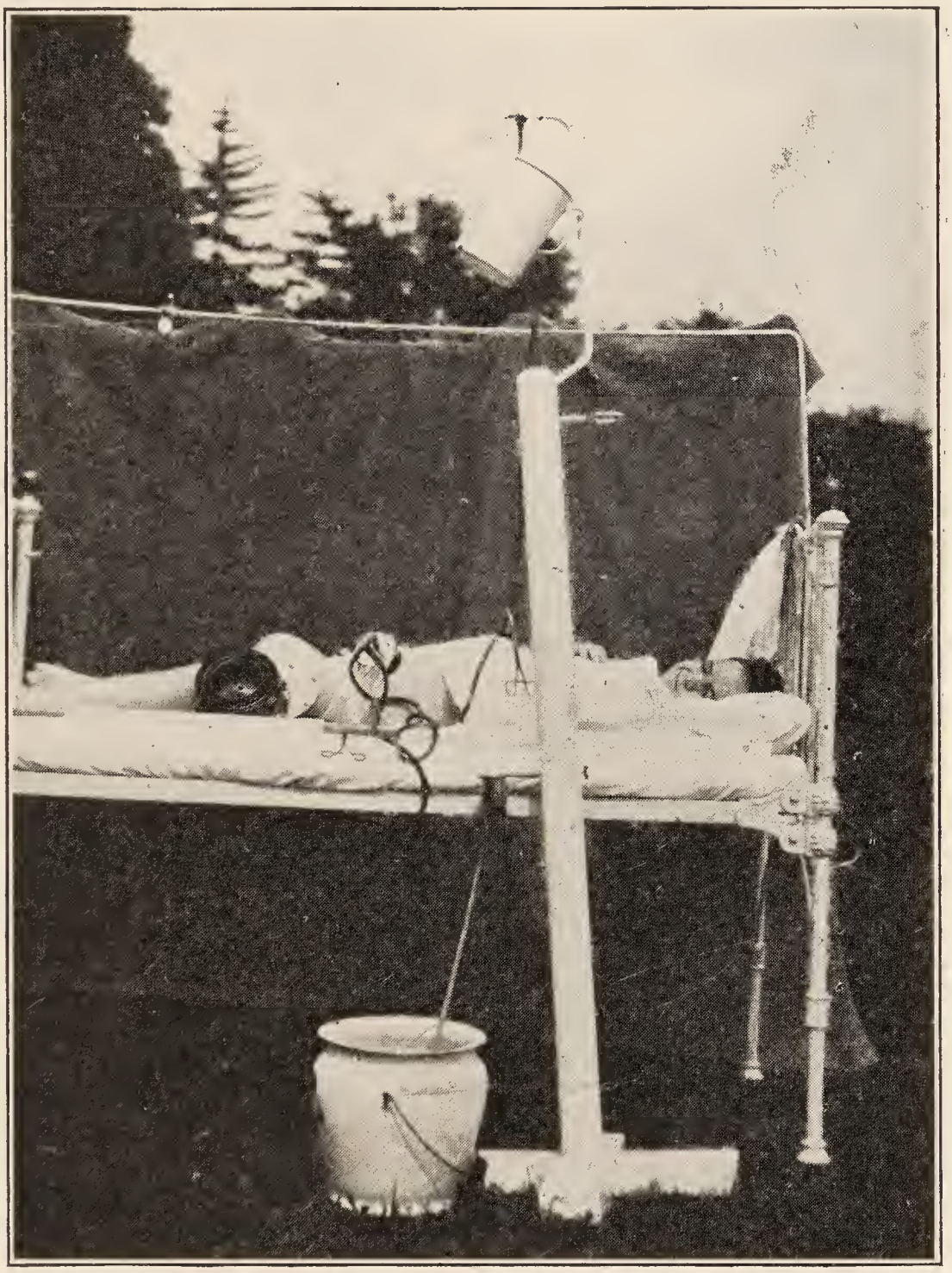


FIG. 177.—Gallie Taylor-tidal irrigator.

or wound by the out flowing fluid and the tissues are milked of bacteris, pus and detritus. The maintenance of the vacuum is dependent, of course, on the water valve. From the valve a piece of tubing goes to the waste bucket. The caps come in two sizes and are made by V. Mueller and Company, 1771 Ogden Avenue, Chicago, Illinois. The water valve is also supplied by them. The authors recommend that the irrigating tank be 18 to 24 inches above the wound and the valve about the same distance below. "Positive Pressure" is maintained for a few minutes and the "Negative Pressure" for a much longer period. At first the secretion is more profuse, but in a few days, it is materially

lessened. The warm hypertonic salt solution (5–10 per cent.) is solvent, tends to stimulate phagocytosis and to produce bacteriolysis and healing (Fig. 177).

Applied to Tuberculous Sinuses, the writer has found, where these are multiple, in order to obtain a vacuum or "Negative Pressure," it is necessary to close with bits of cotton and collodion those of minor importance and direct our treatment to the largest opening.

In the case of small children with a sinus on one of the extremities, it is difficult, if not impossible to get the rubber caps to fit or work well and the following

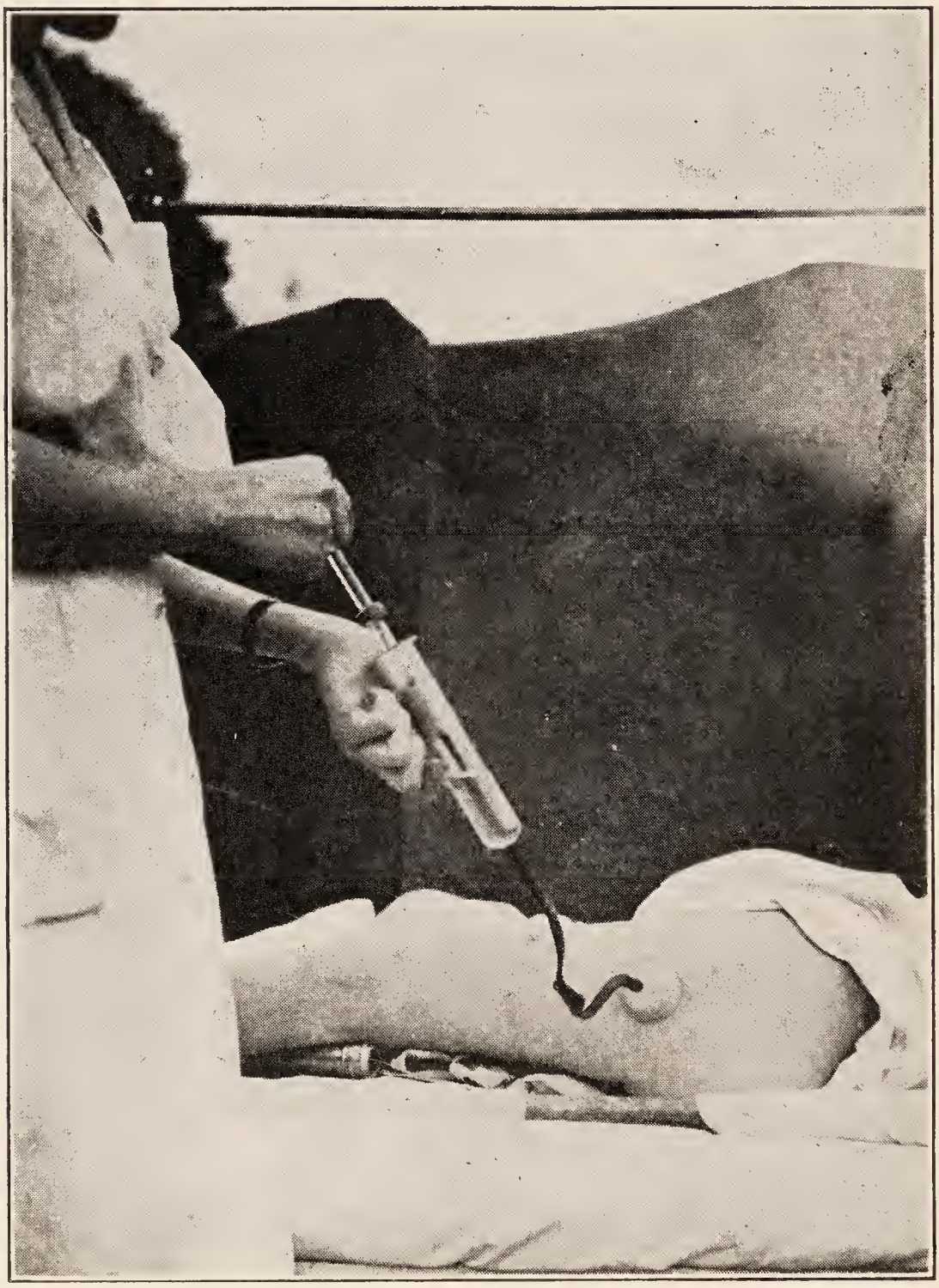


FIG. 178.—Author's apparatus for tidal irrigation.

simple apparatus has been devised by the author. It consists of a four or six ounce glass-syringe with a tubular nozzle on which is slipped rubber-tubing that is rather heavy and will not collapse easily. This tubing is supplied with a stop-cock. In the other end of the tube is slipped the smallest size of glass funnel (Fig. 178).

After sterilizing the whole apparatus and filling the syringe with salt solution, the edge of the funnel is smeared with sterile vaseline and is it then firmly pressed down on the skin around the sinus and pressure is made on the piston until the

whole sinus tract is filled and distended. Then the piston is withdrawn and strong suction will be seen to have occurred as the tissues are sucked up into the funnel for a short distance and the solution is more or less clouded. The suction is more uncomfortable than the distension, but should be borne for as long a period as is reasonable and desirable. To facilitate leaving this in place, the stop-cock is now tightly closed and the syringe can be removed, leaving the funnel *in situ* as a sucker.

The Carrell-Dakin Solution so beneficial in acute infections of bone and soft parts has been tried with no appreciable effect in curing Tuberculous Sinuses.

Beck's Bismuth Paste had quite a vogue and was squirted into sinuses with the aim of bringing the healing medicament into every nook and cranny. Unfortunately, like many other foreign substances, heterogenous, and non-absorbable, bismuth paste is sooner or later extruded from the body, bit by bit, so that a wound or sinus may be kept open over a prolonged period by nature endeavoring to be rid of its presence.

4. *Incision.*—The indications for incision are (1) definite localization of the abscess; (2) pressure symptoms of a disturbing nature, and (3) the possibility of easy and perfect drainage, flushing thoroughly with hot sterile water when the incision is to be dried, sutured and the walls of the cavity approximated by compresses and tight bandages.

The writer is distinctly opposed to the necessarily blind efforts at curetting the vertebral bodies, for the traumatism of healthy tissues leads to extension and not removal of the disease, with the production of septic sinuses, which last for years and result in amyloid disease and death often.

II. **Treatment of Psoas Contraction.**—(1) Fixation on a bed frame is indicated. An inclined plane which can be gradually lowered is to be used to support the drawn leg, and weight and pulley traction by means of Buck's extension usually overcome the trouble when of recent origin. Traction is to be made in the line of the deformity (Fig. 31).

2. In neglected cases, anaesthesia with forcible correction may break up any fibrous adhesions and stretch the shortened muscles (psoas and iliacus). But this procedure is rarely the one to choose. "Brisement forcé" it is called.

3. Tenotomy or myotomy of the tensor vaginae femoris, long head of the rectus and sartorius muscles may be necessary.

4. But, preferably, subtrochanteric osteotomy must be employed (Gant's operation) in resistant cases. This consists of dividing the femur just below the intertrochanteric line with an osteotome and mallet, which operation will be spoken of more at length under hip disease. This, of course, is only to be undertaken, if prolonged traction fails to correct.

III. **Treatment of Paralysis.**—(1) Mechanical treatment is to be employed in all cases with recumbency, fixation, hyper-extension and perhaps extension by means of weights attached to the head and legs. This is the best and most reliable mode of treatment.

2. Of the medicinal remedies, the iodide of potassium in increasing and large doses, and ergot and the application of the cautery over the diseased area, have been recommended, but are of little value without thorough fixation.

3. Hyper-extension (forcible) by the kyphotone or some of the other methods mentioned of applying a jacket have yielded good results at times. Occasionally sufficiently thorough bed fixation is not obtainable and a jacket or brace should be worn in recumbency as well.

4. Laminectomy should be done when the pressure symptoms do not improve under the prolonged treatment after a year or more of recumbency and fixation, but it is a most unwise procedure if avoidable, as the bodies of the vertebrae offer no support and if the laminae are removed there is only the support of articular processes. Paralysis may then recur (Painter).

5. Costo-transversectomy or the removal in an inch or two of the rib and transverse process at the seat of the disease on one side and then puncturing the abscess cavity in the vertebral body by the finger, a probe or curette may yield satisfactory results in prolonged cases and may be tried before lamenectomy is resorted to, if the X-ray and a careful neurological examination seem to point to *pus* and not a thickened meninges as the cause.

Treatment in General.

Treatment in general should aim at obtaining for each case (1) the most nourishing food; (2) fresh air; (3) direct sun rays to *gradually* sunburn or pigment the *entire body*, "heliotherapy;" (4) tonics, such as strychnin, cod liver oil and iron especially. Preparations of beef blood are helpful in the anaemia of amyloid cases. In other words, in these cases the general treatment should be what we would give a case with tubercular disease elsewhere. Many cases are much benefited by residence in a high altitude, as is the case in consumption, with out-of-door life and our cases which have four or five months at the mountain hospital in the summer, all show the benefit in the fall. This we have insisted on since 1897. Suburban hospitals or residences in any event and at all seasons are better places for these cases than the best that the cities afford (Fig. 167). The vaccines certainly seem helpful.

Massage to the extremities and abdomen is desirable in cases long recumbent to help the circulation and nutrition. Exercise, of course, with limitations is permissible and desirable in convalescence.

It is needless to say that the great aim of each surgeon called upon to treat a case of Pott's Disease should be to make his diagnosis as soon as possible and institute the most thorough means of persistent immobilization and hyper-extension *early*, to prevent the increase or the production of this dreadful and disfiguring deformity. There is no question that the responsibility for severe deformity in such cases of which we see evidence constantly, rests on the family physician, who by ignorance or halfway measures of his own or by attempting to shirk his duty to his patient in referring him to unskilled instrument-makers, whose pathology is an unknown quantity, reaps his reward in seeing his patient gradually become deformed.

An exception to this anathema is the folly sometimes found in parents, who will not carry out the prescribed treatment to the letter.

Records of Cases.—When the patient is first seen the lead tape should be molded along the spinous processes to show any deviation from normal. The molded tape is then laid edgewise and used as a ruler on the patient's history

and with a pencil a record curve is made. At each subsequent visit a similar tracing is made so that the efficacy of the treatment in preventing the increase of the deformity may be observed and more rigid methods employed if necessary (Figs. 154 and 168). One should not be content with single antero-posterior X-rays of the spine for diagnosis in this disease, but *lateral views* should be made as well, at stated intervals, so that the progress of the disease and result of treatment might be noted.

Tubercular Sacro-iliac Disease.

This comparatively rare affection occurs when the tubercular process attacks the sacro-iliac joint and is readily recognized by X-ray study taken in conjunction with the lameness, muscle spasm and pain which accompanies it and the weight-bearing is thrown on the sound side and seen when the patient stands. Much more prolonged recumbency is required to cure this disease than in Lumbar Pott's Disease and the plaster jacket may have to be extended to a double spica.

CHAPTER XV

NON-TUBERCULOUS DISEASES OR AFFECTIONS OF THE SPINE

1. Rachitic Kyphosis.

Frequently in rickety infants before the third year, one sees a marked angular spinal deformity, which may be mistaken for Pott's Disease in the dorso-lumbar region, with lordosis in the cervical and upper dorsal region. The diagnosis is not difficult if one bears in mind the other symptoms of rachitis, viz: the square head, beaded ribs, enlarged radial epiphyses, prominent abdomen, Harrison's groove, open fontanelles, bent extremities, etc.

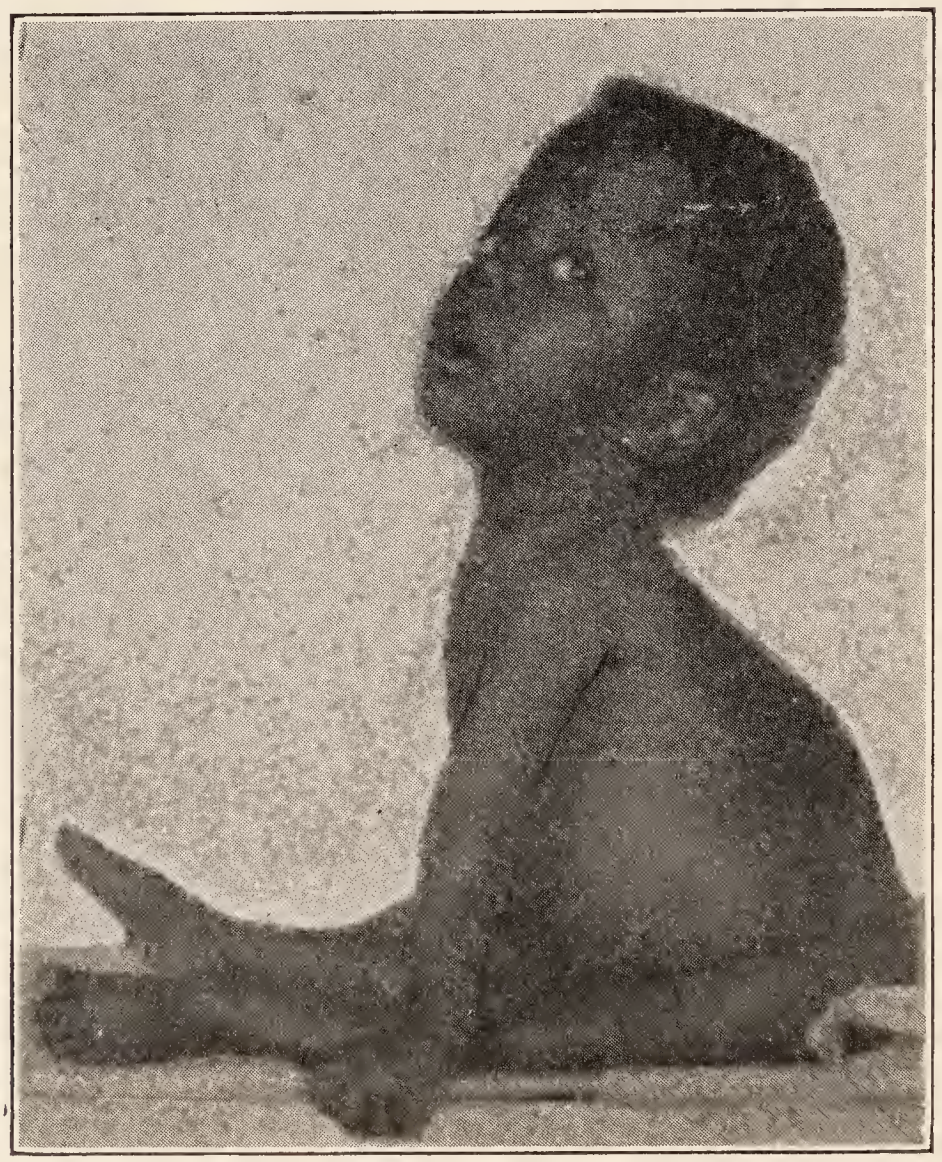


FIG. 179.—Rachitic dorso-lumbar kyphosis.

If one places the child on the face and the deformity is of short duration the curve can be flattened by pressing with the palm of the left hand, while with the right the child's legs are raised to produce hyper-extension of the spine. It should be kept recumbent on its back on a frame until the acute symptoms of rickets disappear. If of long duration, massage should be given morning and evening to the spinal muscles and hyper-extension employed by means of a

padded block on the Bradford frame, as indicated under Pott's Disease. In either case recumbency is indicated, together with good hygienic treatment, such as cold sponging, proper food and tonics, to be spoken of later more in detail under rickets (Fig. 179).

At times it is advisable to put the child on a kyphotone and apply a plaster jacket, made to lace preferably, or an antero-posterior brace to be described under Section 14 of this chapter may be employed.

If the rachitic kyphosis is allowed to persist we may see when the child walks or stands the "rachitic attitude" with exaggeration of the dorsal kyphosis and lumbar lordosis as a result of abdominal muscular relaxation and forward tilting of the pelvis (Fig. 180). Or if the infantile kyphosis is more of the lumbar type the dorsal curve may become compensatorily less marked with the resulting "flat back" and upward tilted pelvis.

Lateral curvature of the spine may be a sequela of untreated rachitic kyphosis from the habitual faulty attitude and weakness together with lateral body bending or twisting of the spine or pelvis during the period of softening of the bones.



FIG. 180.—The Rachitic attitude ("Round-hollow Back").

2. Typhoid Spine.

Gibney[1] first described a spinal disease, simulating Pott's Disease, but without deformity, which followed typhoid fever, or occurred during its course, in which the articulations or perispondylitic structures become secondarily affected. It is characterized by pain, weakness and stiffness. The diagnosis is clear from the history of the febrile attack and relief is afforded by recumbency, opiates, the Paquelin cautery, electric hot air blast, massage and later a spinal brace. Osler, Keen, Park, Quincke and others have reported cases.[2]

3. Scarlet Fever Periostitis and "Gonorrhoeal Rheumatism" of the Spine.

These troubles are rare and result in pathological changes and symptoms, which resemble typhoid spine. Gonorrhoea often results in stiffness of the spine from adhesive ankylosis or proliferative exostoses and we consider it one of the causes of rheumatoid arthritis of the spine usually spoken of as spondylitis deformans, to be discussed under that heading later (Section 6). Much benefit may result from a sterile emulsion of gonococci as a vaccine, to be spoken of further on in diseases of the extremities.

Locally the treatment is the same as in typhoid spine, the plaster of paris jacket often affording great relief.

[1] Trans., Amer. Orth. Assoc., vols. ii and iv.

[2] Johns Hopkins Hospital Reports, vol. iv, page 80.

4. Syphilitic Disease of the Spine.

In children specific bone disease may be inherited or in older patients be acquired, but one rarely finds gummatous lesions in the spine, the long bones showing oftener the characteristic periostitis or osteochondritis at epiphyseal and diaphyseal junctions. Should the spine become secondarily involved the symptoms and treatment would be the same as those found under tuberculosis, with the addition of the therapeutic measures demanded for lues. Of course, it is possible to imagine tuberculous osteitis of the vertebrae and syphilitic lesions elsewhere, but Bradford and Lovett[1] rather doubt a primary specific osseous manifestation in the spine.

5. Acute Arthritis of the Occipito-Atlantoid Articulation.

Whitman calls attention to this affection which may follow tonsillitis, diphtheria or other contagious diseases infecting the pharynx, by extension. It resembles a localized rheumatism and can be distinguished from tuberculous disease by the acute onset and from acute torticollis by the fact that all motions are restricted and not simply those controlled by the sterno-cleido-mastoid and trapezius.

The treatment should consist of the local treatment of the causative disease in the fauces and pharynx and a fixative support in recumbency by means of sand bags. This should be followed later by massage and manipulations to overcome the subsequent stiffness.

6. Spondylitis Deformans.

Synonyms.—Osteo-arthritis of the spine; ankylosis of the spine; rheumatism of the spine; and rheumatoid arthritis of the spine; spondylose rhizomèlique of Marie. (When all joints are involved this constitutes the "ossified man" of the museums.)

Pathology.—There is a chronic ankylosing inflammation affecting primarily the ossification of ligaments and prevertebral coverings of the spine, a form of ossifying periostitis, which binds the vertebrae firmly together. It may be limited to a few vertebrae, to one region or include the whole spine and the articulations with the ribs. It may be a part of a general rheumatoid arthritis involving other joints, but under the name spondylitis deformans the spine alone is understood to be involved and there is a proliferation of bone in this region as exostoses. This "lipping," as it is known, is shown especially well in lateral X-ray views, as minute points or projections from the normally smooth articular edges and more or less clouding or obliteration of the articular spaces. It may be a sequela of chronic gastritis, non-tubercular lung involvement, bad teeth, especially abscesses at the roots, chronic tonsillitis, sinusitis, purulent antra, acute inflammatory rheumatism, traumatism, gonorrhoea in young adults or other infections but is more common in women past middle life. According to Nichols of Harvard the causes are various and the different types are simply different stages of the same process (Fig. 181). A chronic focus of infection anywhere in the body may lead to joint involvement.

Symptoms.—Stiffness of the spine follows an acute onset and gradually increases. Muscular spasm, headache as of a "steel band around the brow,"

[1] Second edition, page 155.

weakness in the extremities (more often in the arms) and radiating, peripheral pain from pressure on nerve roots as they emerge from the spinal cord may extend to arms or legs depending on the region involved. Neurasthenic symptoms are characteristic. Any region or all regions of the spine may be involved. At times the muscular spasm in cervical disease with spasmodic head movements or "dragging" as it is called by the patient is a most distressing symptom, until relieved by an ankylosis or subsidence of the symptoms of inflammation. Distinct localized swelling is sometimes present and palpable or even visible over the transverse and spinous processes. A strenuous, nervous life, overwork, ill health, or privations in food and comforts will be found to play a part in the aetiology, especially associated with a chronic "focal" infection, which we must seek out and eliminate if possible. Some patients describe the muscular spasm giving a sensation, in cervical disease, as if they "were horses in check reins" and are constantly moving the head as much as possible in the effort to relieve this tension and spasm in the trapezius and deeper muscles. Some have "pain

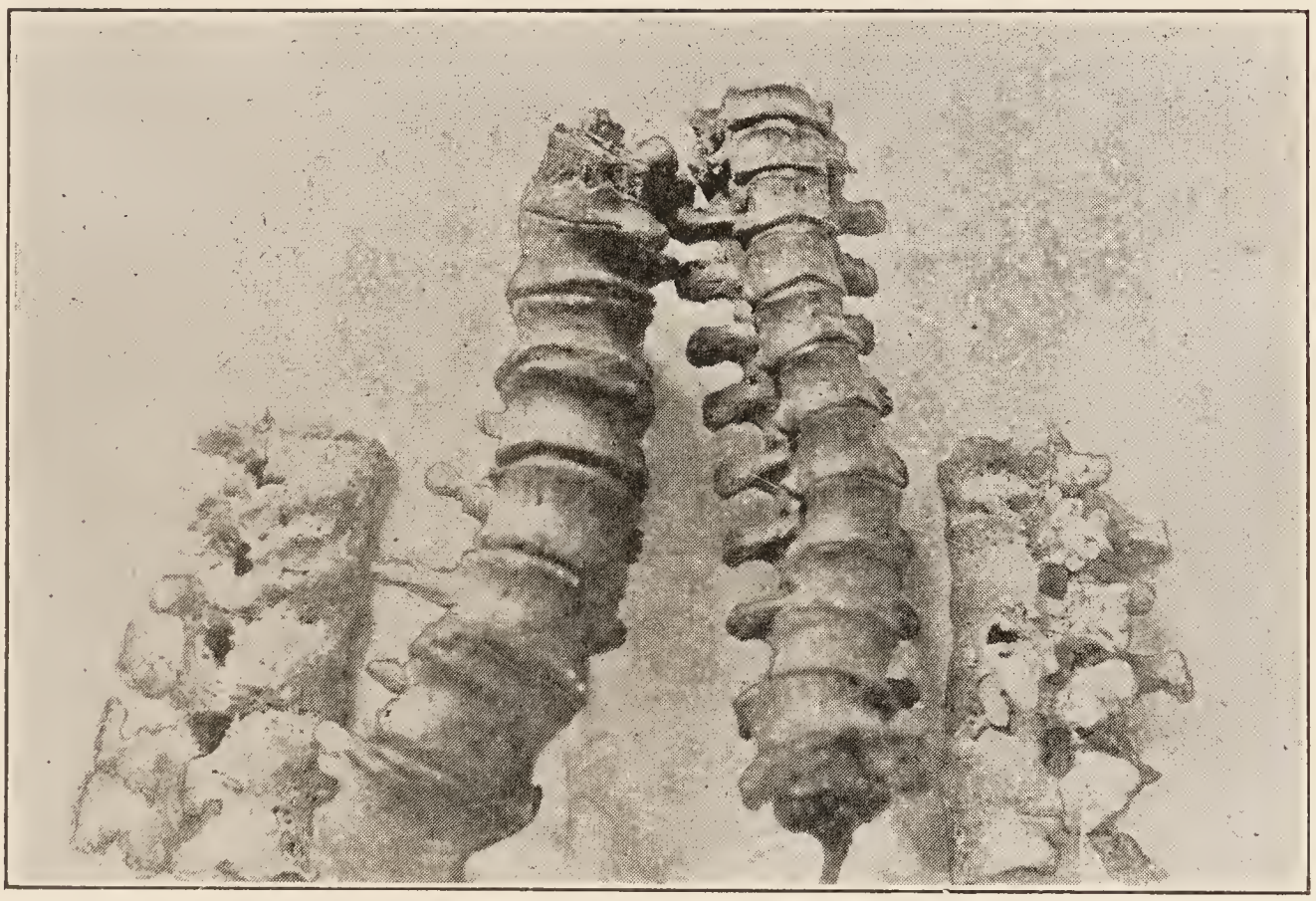


FIG. 181.—Spondylitis deformans, showing osteophytes on either side.

across the shoulders as though carrying an iron bar" and some weakness in legs. Nearly all these cases are neurotic, irritable and high-strung from the prolonged suffering. The duration of the disease usually covers several years and is chronic. The pain fortunately stops after a time, when ankylosis occurs, but is of course relieved sooner by treatment and elimination of the focal infection. The self-limitation of this disease although covering a prolonged period often renders these subjects easy victims to the belief at the end of the painful stage that the relief has come from Christian Science, Osteopathy, Chiropraxy or some holy water from a Shrine, which was tried at the psychological moment. There is no angular deformity as in Pott's Disease, but the whole spine with ribs may become ankylosed and bowed concavely forward. The cervical spine is usually ankylosed last of all. Breathing is abdominal when ankylosis occurs between the dorsal vertebrae and the ribs (Figs. 182 and 183).

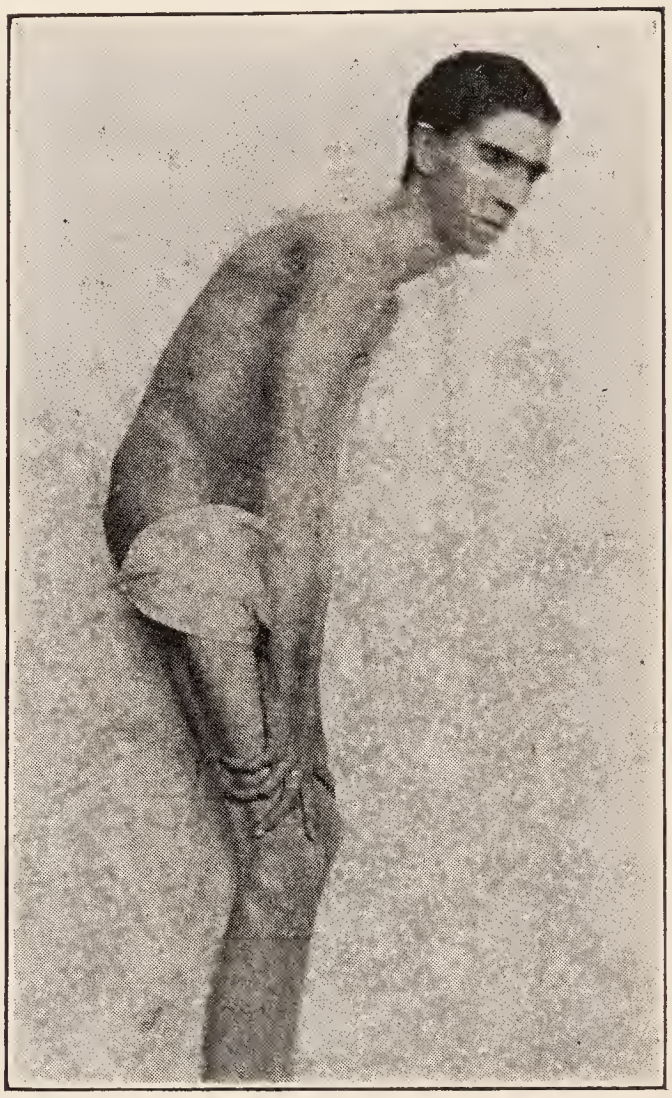


FIG. 182.—Spondylitis deformans (showing maximum degree of extension).



FIG. 183.—General rheumatoid arthritis involving spine also. Still's disease or so-called atrophic arthritis. For X-ray of hands, see Fig. 384.

Treatment.—Detection, removal and cure of the focal infection is the first essential. Tonics, such as cod liver oil, strychnin or iron should be given. Rest of the part in the acute stage is of the first importance. Of local remedies, the Paquelin cautery, self-suspension by the head-sling, recumbency with head traction, the Thomas collar or steel head support, a back brace or plaster jacket afford most relief during the acute stage. Especially if pain is increased on motion, a brace will relieve the muscular spasm and prevent deformity. Rubber heels lessen the jar on the spine in the acute period. Massage and Swedish movements are only helpful later and intensify the trouble in the early stages. Electric diathermy and heliothermy are helpful as routine daily treatment.

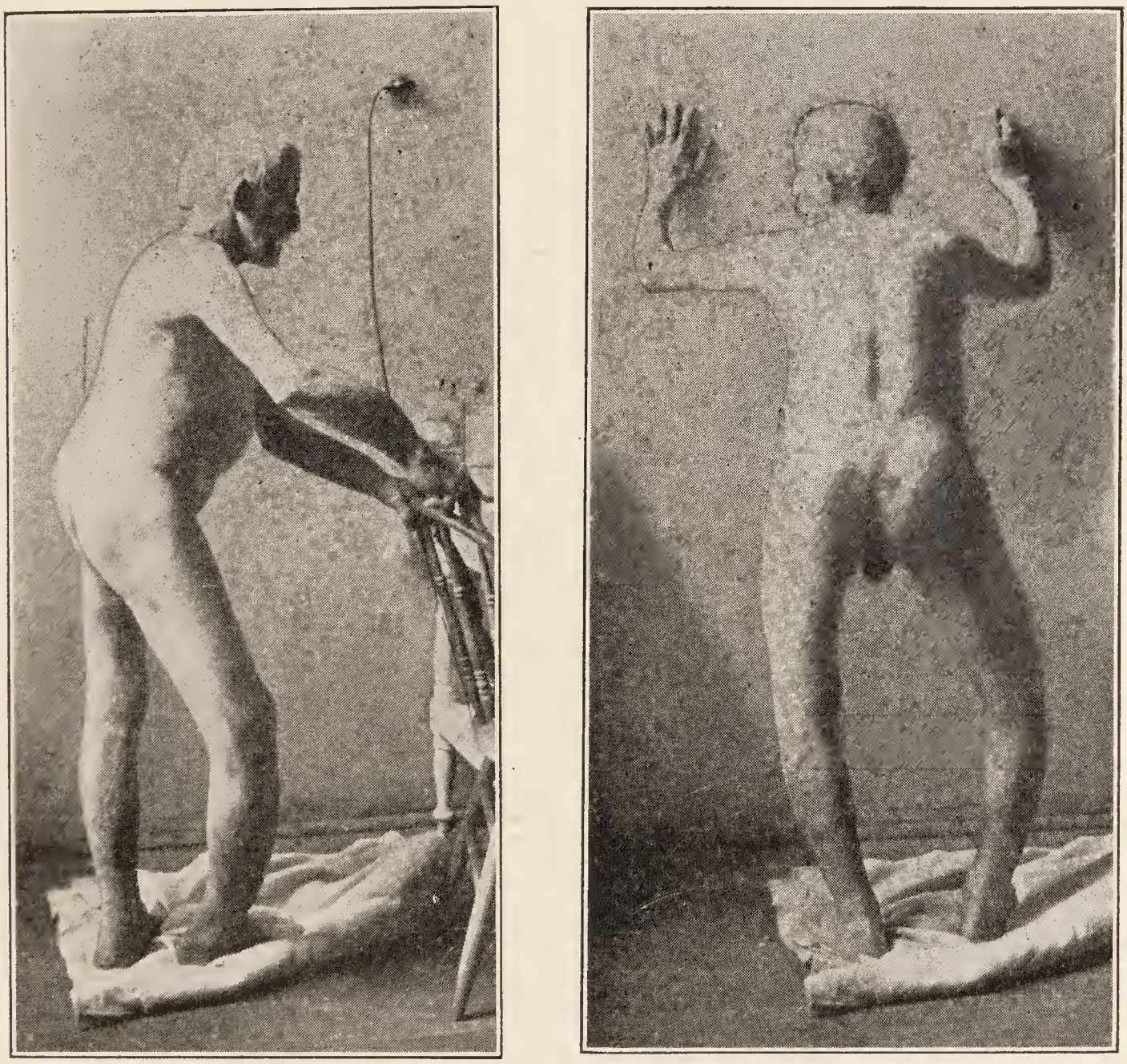


FIG. 184.—Paget's disease with long cervico-dorso-lumbar kyphosis. Bowed arms and legs and enlarged head. (*Courtesy of Doctor A. D. Atkinson.*)

7. Osteitis Deformans or Paget's Disease.

This disease was first described by Paget in 1877[1] and hence bears his name. It is a chronic affection of the bones, characterized by kyphosis of the spine and hypertrophy and softening of the bones, and those bearing weight become unnaturally curved and misshapen (Figs. 184).

Pathology.—A section of an affected bone shows it to be markedly increased in size and somewhat in length by a combination of internal osteoporosis and a formative osteitis under the periosteum.

[1] Med. Chir. Trans., 1877, vol. xl, and 1882, vol. lxv.

This disease occurs in adult life and chiefly in old age, is rarely in one bone but usually is symmetrical and general in its distribution. The spine is kyphotic, as before stated, the head enormously and progressively enlarged and the arms and legs are bowed. Pain is rarely present and then of a subacute rheumatic type. There are no marked symptoms. The aetiology is unknown and treatment is palliative by means of braces to prevent the bending of the spine and legs; a C. F. Taylor back brace is to be used for the former and supporting braces for the latter.

8. **Cancer of the Spine.**

Primary malignant bony growths in the spine are remarkably unusual in children. However, sarcoma is more often seen than carcinoma and when found other portions of the body will have first shown evidences of the disease.



FIG. 185.—Osteo-sarcoma of the spine. Fourth to eighth dorsal vertebral bodies and adjacent ribs involved. Little or no posterior curvature.

If present in the spine, the symptoms are severe as elsewhere, the pain and paralysis from pressure on the nerves and cord are constantly present, the course is rapid, the cachexia as shown by the general appearance, anaemia and systemic depression is noticeable. Early dissolution may be anticipated. No remedies save anodynes are of service, and mechanical appliances are helpful if fixation is perfect, in the relief of pain, and the kyphosis, so characteristic in

tuberculosis of the spine, is not present; one rather finds in lumbar disease on palpation in the abdomen the large growth. If the contour of the spine is changed posteriorly it is rather as a rounded tumor mass than as an acute angular curvature (Figs. 185 and 186).

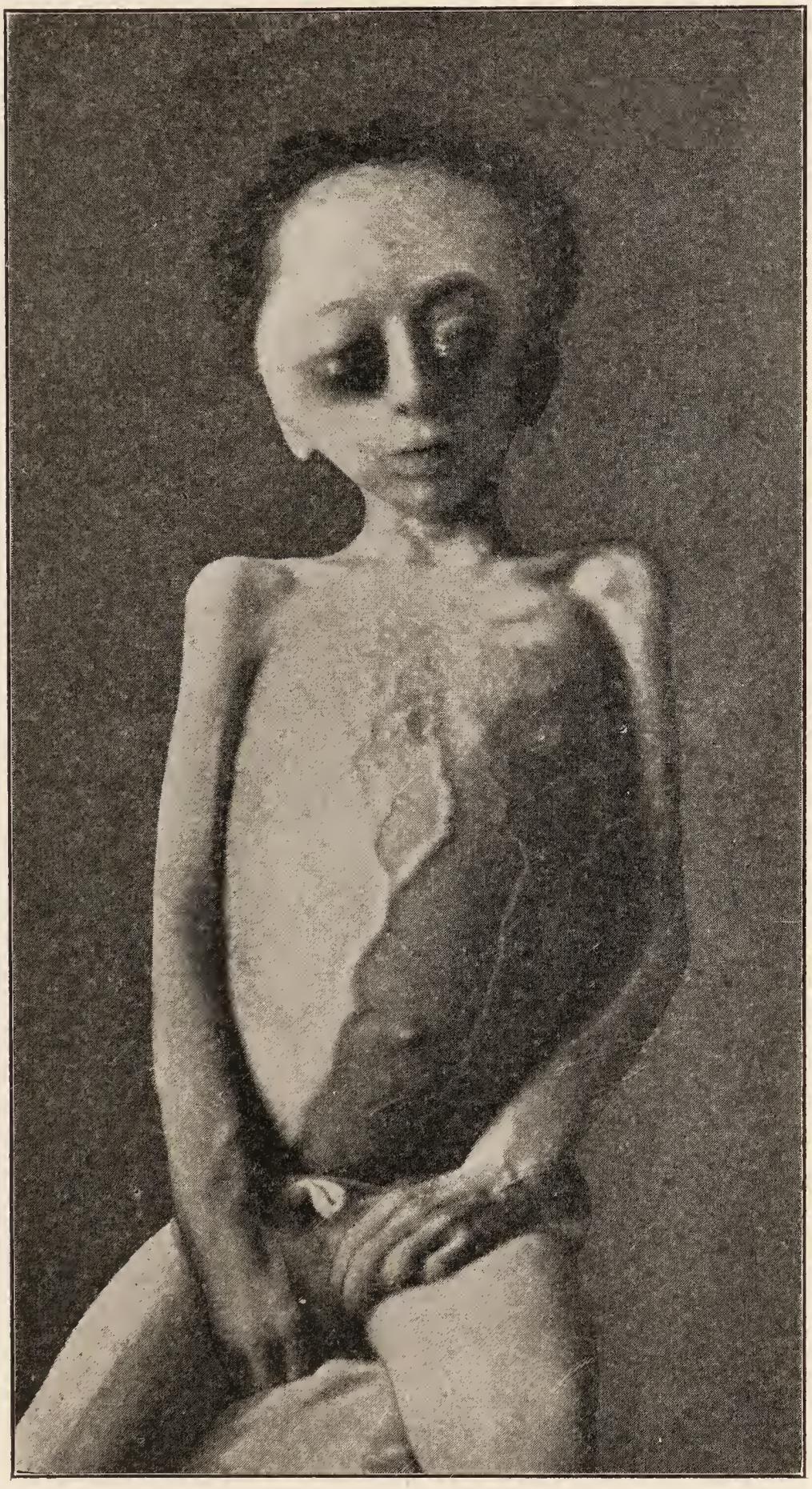


FIG. 186.—Sarcoma of the spine showing venous stasis and metastatic growth in orbit. (*Young.*)

6. **Traumatisms to the Spine.**

Severe sprains, slight or severe fractures of the spine may occur, especially in the cervical region as from diving accidents, but the X-ray, recumbency and supports together with head traction in bed will clear up the diagnosis of traumatic cases in a comparatively short time, especially when taken in conjunction

with the history of immediate onset of the trouble after an accident, in contradistinction to the gradual onset in tuberculous disease.

Fracture in the dorsal region, according to Kummel[1] with symptoms of pain and weakness may result in a rounded angular deformity like Pott's Disease, which in untreated cases may increase and persist indefinitely, from a rarefying osteitis.

Fracture-dislocation is more common in the cervical and lumbar region than in the dorsal (Fig. 187 A, B and C).



FIG. 187*A*.—X-ray of fracture dislocation of the dorso-lumbar spine, sensory and motor paralysis with recovery. Before laminectomy.

Compression or impacted fractures of the vertebral bodies without deformity may occur as the result of falls from a height and Painter[2] has reported cases of traumatic rupture of the posterior spinous ligaments producing a deformity similar to Pott's Disease (Figs. 188 and 189).

Diagnosis as to the nature of the trouble is to be made by a careful review of the history and examination of the case, with the aid of the X-ray (Fig. 190).

Treatment.—Fixation in plaster of paris in cases of fracture or recumbency with head and leg traction, so often omitted, must be used. In the early cases

[1] Deutsche Med. Wochens., 1896, No. 11.

[2] Trans. Amer. Ortho. Assoc.

approximation of the fragments if obtainable is to be tried for. Some form of cervical or spinal support is to be used until all symptoms of weakness disappear. Wiring the spinous processes together has also been employed.

Pressure symptoms on the cord require operative measures and must be relieved if due to bony spiculae by their removal when other means fail, but in all cases spinal immobilization is essential. Massage is useful later, as in fractures elsewhere, to restore function as far as possible.



FIG. 187*B*.—X-ray of fracture dislocation of the dorso-lumbar spine, sensory and motor paralysis with recovery. After laminectomy.

10. Acute Osteomyelitis of the Spine.

This is an uncommon disease, occurring usually in young adults in the lumbar region and less than 50 cases are recorded.[1] Like all acute inflammations, its onset is sudden with chill or convulsion, fever, marked pain, tenderness over the spine (unlike Pott's Disease) and pyaemic constitutional symptoms. A typhoidal condition frequently supervenes. Abscess and paralysis are common complications but the former may extend in an anterior direction and escape

[1] Hahn, Beitrage zur klin. chir., Bd. 45, H. 1, page 899; Muller, Deutsche Zeitschrift fur Chir., Bd. 41; Makins and Abbott, Amer. Surg., May, 1896; Chipault, Gaz. des Hop., 1897, lxx, page 1442; Riese, Centralbl. fur Chir., 1898, S. 585; Tixier, Bull. Med., June, 1895.

detection. Large vertebral sequestra may result from the bone necrosis. The death rate is stated at about 60 per cent. The streptococcus or staphylococcus are usually responsible. Cases involving the spinous or transverse processes show much less severe symptoms and are more accessible for treatment.

Treatment.—Necessarily immediate incision is indicated with the subsequent treatment given all acute abscesses, and the spine is to be supported in recumbency by a jacket or brace during the rapid formation of new bone to prevent distortion, but angular curvatures similar to Pott's Disease rarely result from this cause.



FIG. 187*C*.—X-ray of fracture dislocation of the dorso-lumbar spine, sensory and motor paralysis with recovery. Lateral view showing over-riding of the first and second lumbar vertebrae.

11. The Neurotic or Hysterical Spine. "Railroad Spine."

This condition is more common in female adults of the nervous or neurasthenic type, but in some instances the symptoms appear to be the direct result of slight injuries. There may be no deformity, but usually there is a drooping of the shoulders, from general atony.

One of the chief characteristics is the extreme local tenderness (which we do not see in Pott's Disease) in a certain region of the spine more commonly at

or near the vertebra prominens. This is easily detected by palpation and it will be found that the skin is said to be hyperaesthetic at these definite points. There is no pain at the peripheral distribution of the nerves as in tuberculous kyphosis. They suffer much with backache and tire easily. Many are only cured after the damage suit is settled.

The treatment should include tonics, general attention to hygiene, rest, the cautery for its mental effect, massage to the weak region and a spinal support if necessary. Other cases require vigorous gymnastics.

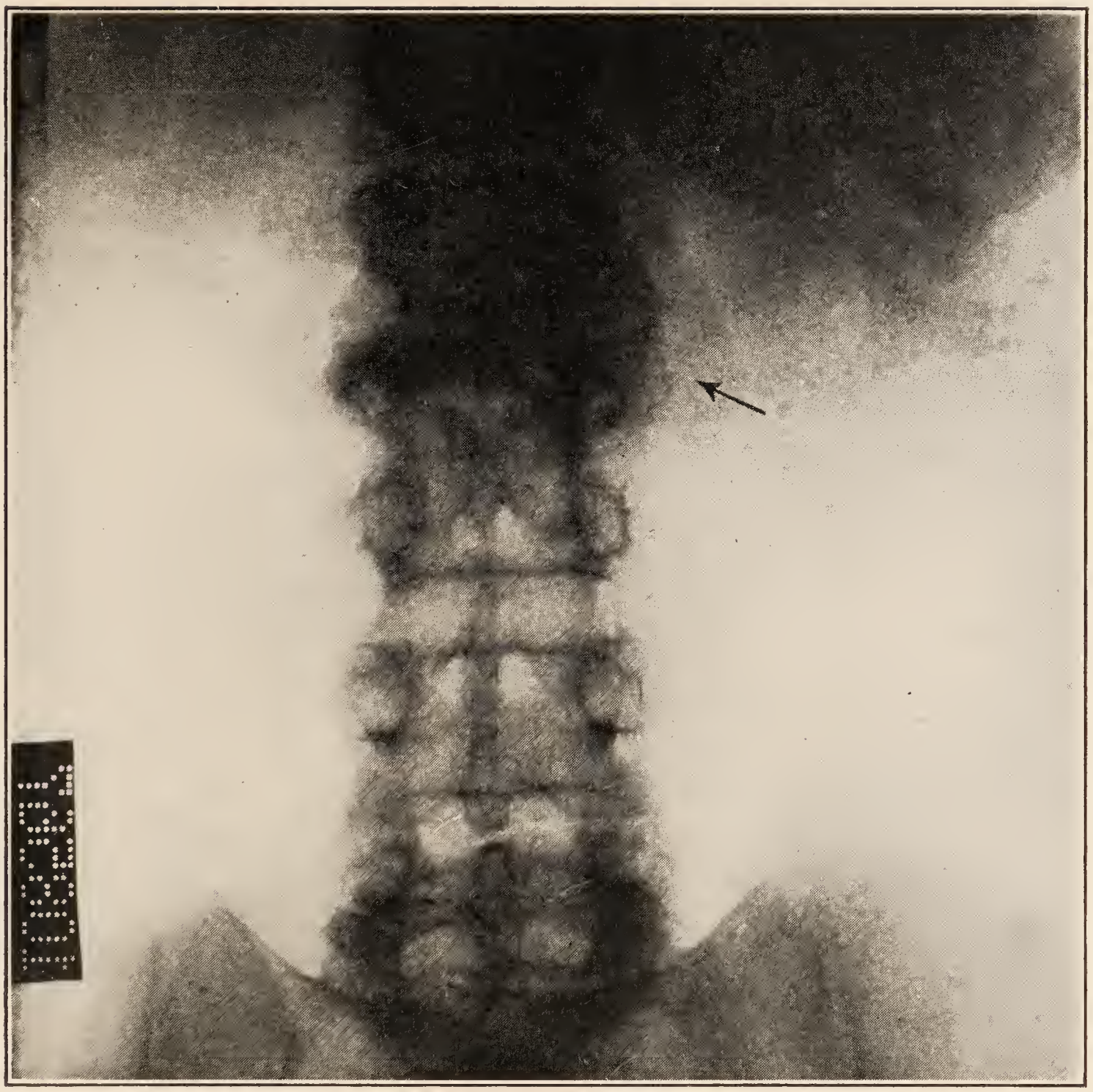


FIG. 188.—Compression fracture of the spine, antero-posterior view. (*Courtesy of Doctor Charles A. Waters from the Johns Hopkins X-ray Laboratory.*)

12. **"Backache."**

This may be a condition associated with lordosis in overworked and pregnant women, requiring treatment. It is also found often in badly deformed cases of hunch-back and coxalgia, with marked flexion and adduction deformity of the legs, associated with lordosis.

Treatment.—The acute stage is best treated by recumbency, massage and the cautery, followed by strapping of the back with intersecting strips of

adhesive plaster. The belladonna plaster used so frequently by the laity may afford this supporting treatment, as well as having its anaesthetic effect on the pain.

Some light form of steel brace or plaster jacket may be necessary. For a pendulous abdomen, an abdominal supporting bandage and perineal straps put on in recumbency, with the pelvis raised, is essential in the atonic with a tendency to enteroptosis, but should be supplemented with leg and body raising exercises and massage to prevent further muscular atrophy.

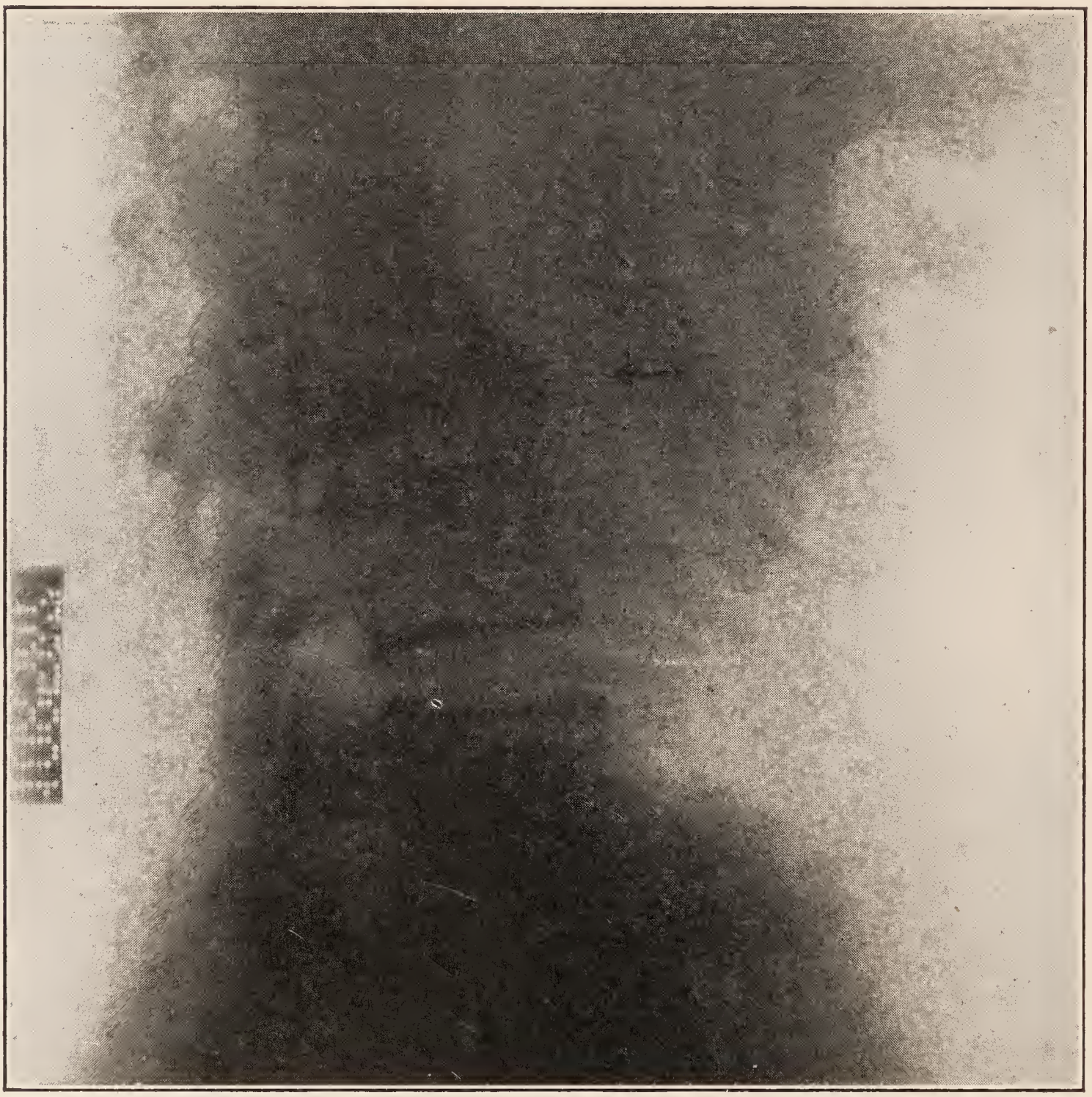


FIG. 189.—The same, lateral view.

13. **Spondylolisthesis.**

This is a condition first described by Killian in 1854 and more thoroughly investigated by Neugebauer in 1890, in which one of the bodies of the lumbar vertebrae, usually the fourth or fifth, slip forward and downward, making the brim of the pelvis narrower antero-posteriorly than it should be normally. It is therefore chiefly important from an obstetrical standpoint. Lordosis is increased, but the spinous processes are not depressed, as one would suppose, but the laminae seem stretched, elongated or separated. It may be due to

disease, injury or congenital malformation. The pain, if present, is best relieved by a plaster jacket or brace.[1]

14. Antero-posterior Curvatures of the Spine.

Under these we have the long curves involving the whole spine in the kyphosis seen in infancy (when the baby cannot hold the head up), in old age and after acute illnesses, and as a sign of weakness. When a child grows up normally, there is a convexity forward in the cervical region from increased muscular

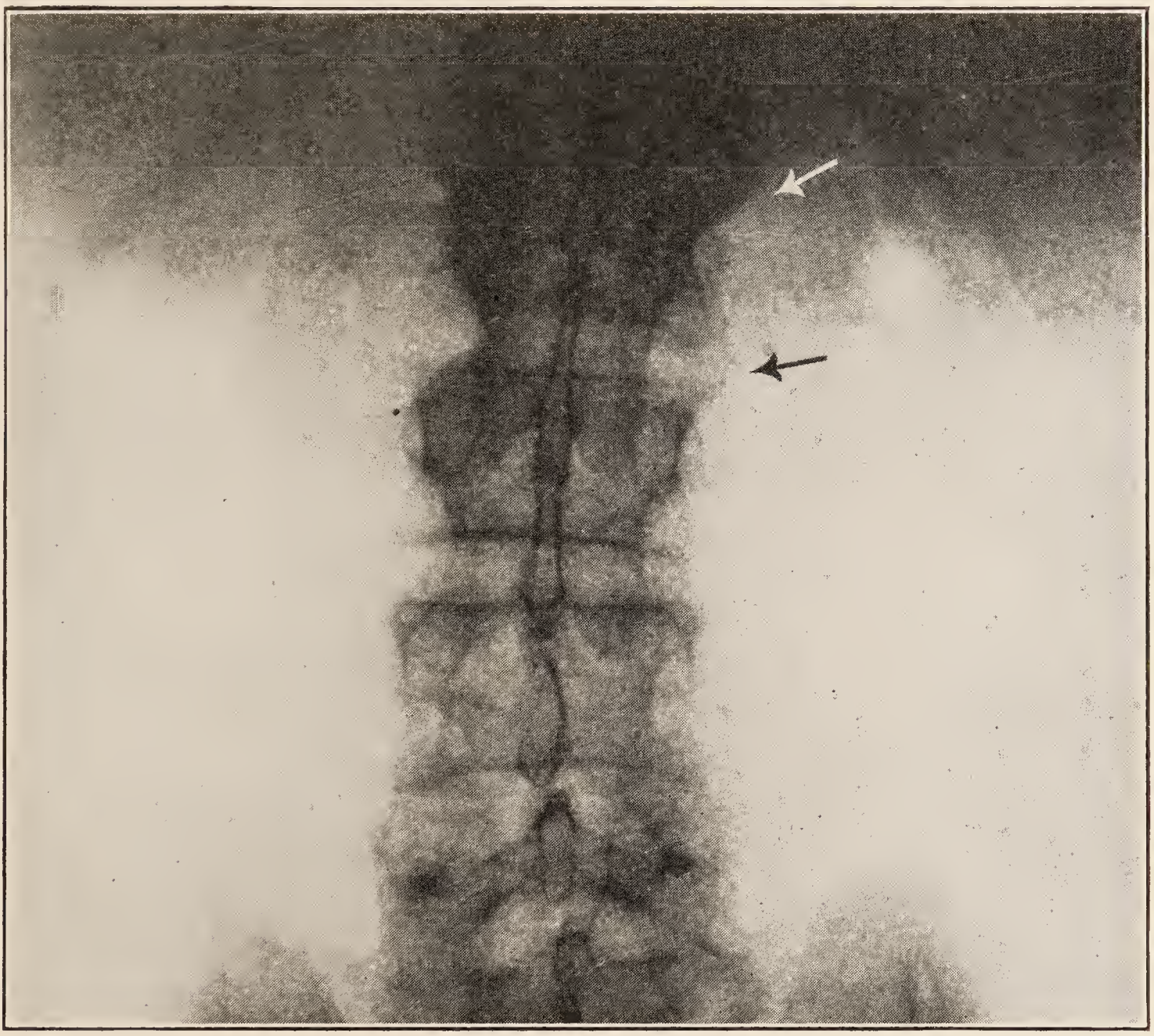


FIG. 190.—Lateral bony bridging between the first and second lumbar vertebrae due to infectious osteo-arthritis. Very similar in appearance to callus formation after fracture. Compare Fig. 188.

power, as the head is held erect, the dorsal convexity backward lessens somewhat and as the thighs are extended and the child stands the pelvis tilts downward and forward producing the normal convexity forward in the lumbar region. Now should anything occur to lessen the power of the intrinsic spinal muscles or cause weakness, more or less deformity will occur, as the attitude departs from the normal. Various habitual attitudes and occupations tend to produce "round shoulders" or "round back," known as a "postural kyphosis," which is seen in children and adults alike, but it is more easily corrected in the former than the latter, before bony changes from functional transformations and osteo-

[1] Lovett, Trans., Amer. Ortho. Assoc., vol. x, page 22.

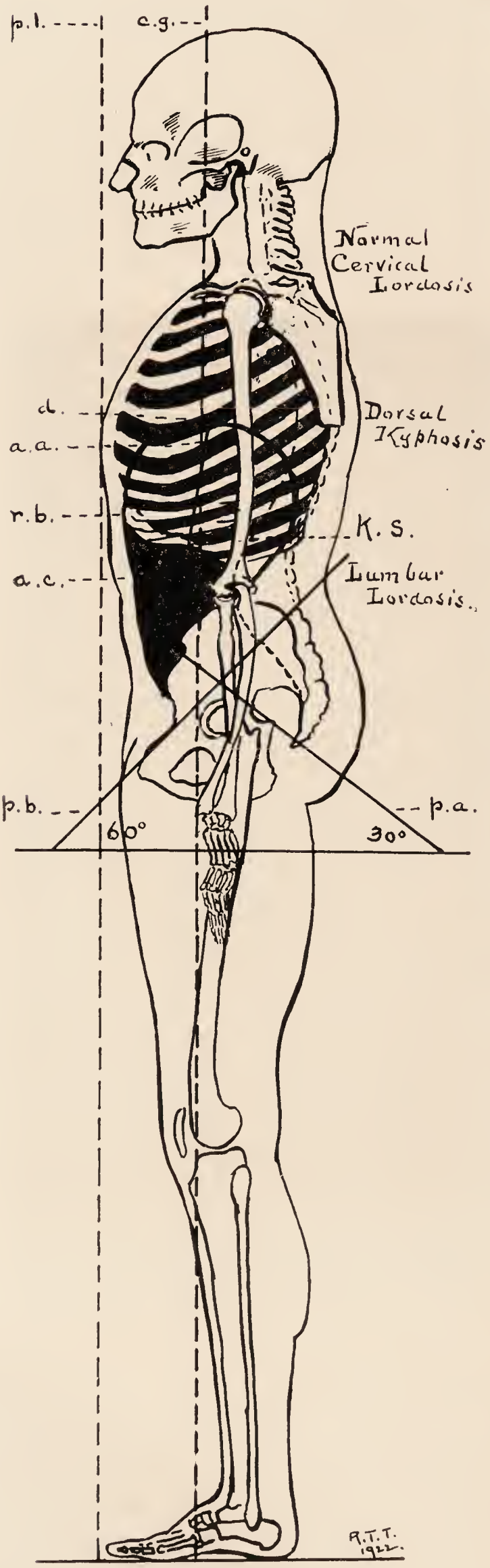


FIG. 191.

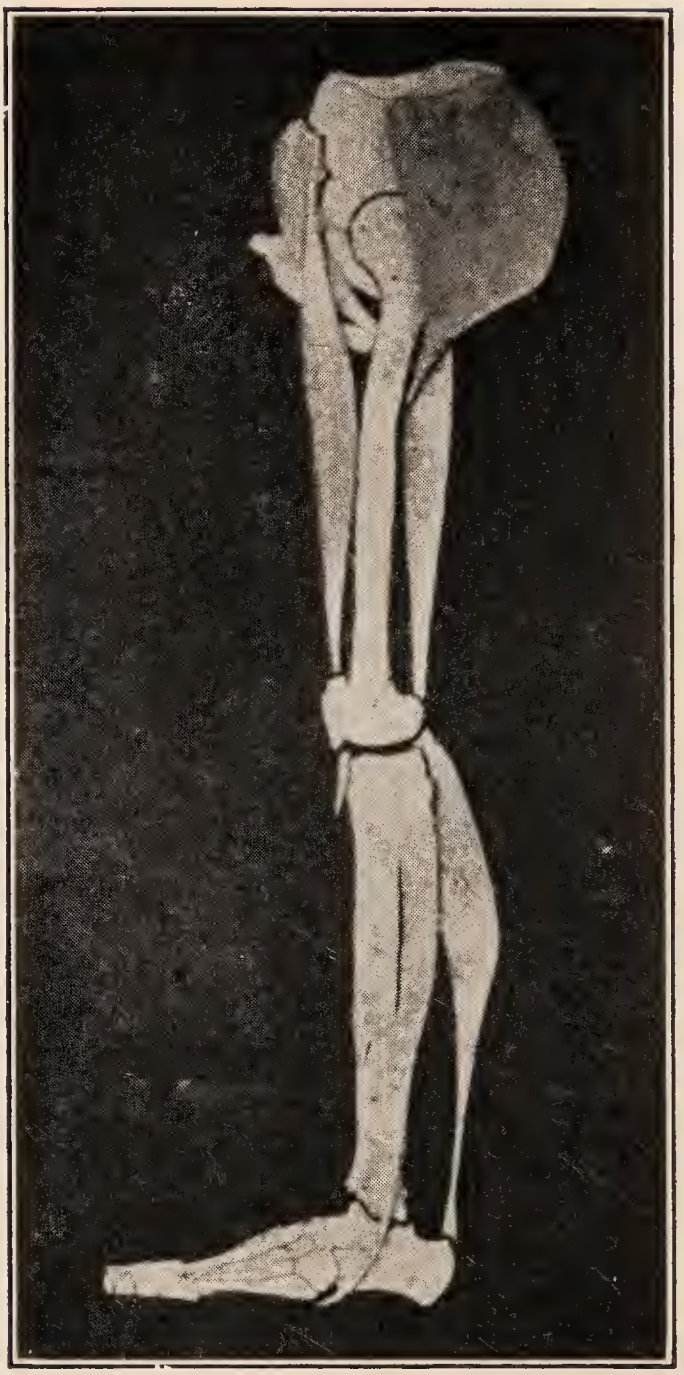


FIG. 192.

FIG. 191.—Correct standing posture.

p.l., posture line which touches chest, but does not touch nose, abdomen or tips of toes; *c.g.*; centre of gravity line which passes through the angle of the jaw, anterior to the shoulder, lumbar spine, hip, knee and ankle joints; *d.*, dome of diaphragm ; *r.b.*, "rib basket;" *k.s.*, "kidney shelf;" *p.b.*, line of pelvic brim making an angle of 60 degrees with the horizon; *p.a.*, line of pelvic axis making angle of 30 degrees with the horizon and about 110 degrees with *a.a.* or axis of abdominal cavity or *a.c.* which is seen to be pyriform with apex down and very much smaller below than above. (*Suggested to Author by Goldthwaits' article.*)

FIG. 192.—Equilibrium maintained by equal muscular balance of anterior and posterior muscles at hip, knee and ankle.

sclerosis have occurred. Frequently when the dorsal kyphosis is much increased, lumbar lordosis becomes exaggerated compensatorily in maintaining the equilibrium and the child is not only stoop shouldered and narrow chested, but sticks out the abdomen in an awkward unsightly manner. This is spoken of as a "hollow-roundback;" at times we see the manifestation of weakness chiefly, as a lordosis with swayback and prominent abdomen alone. The aetiology can be put down to faulty attitudes in sitting, reading and standing, poor respiration due to obstruction to chest expansion from adenoids, enlarged ton-

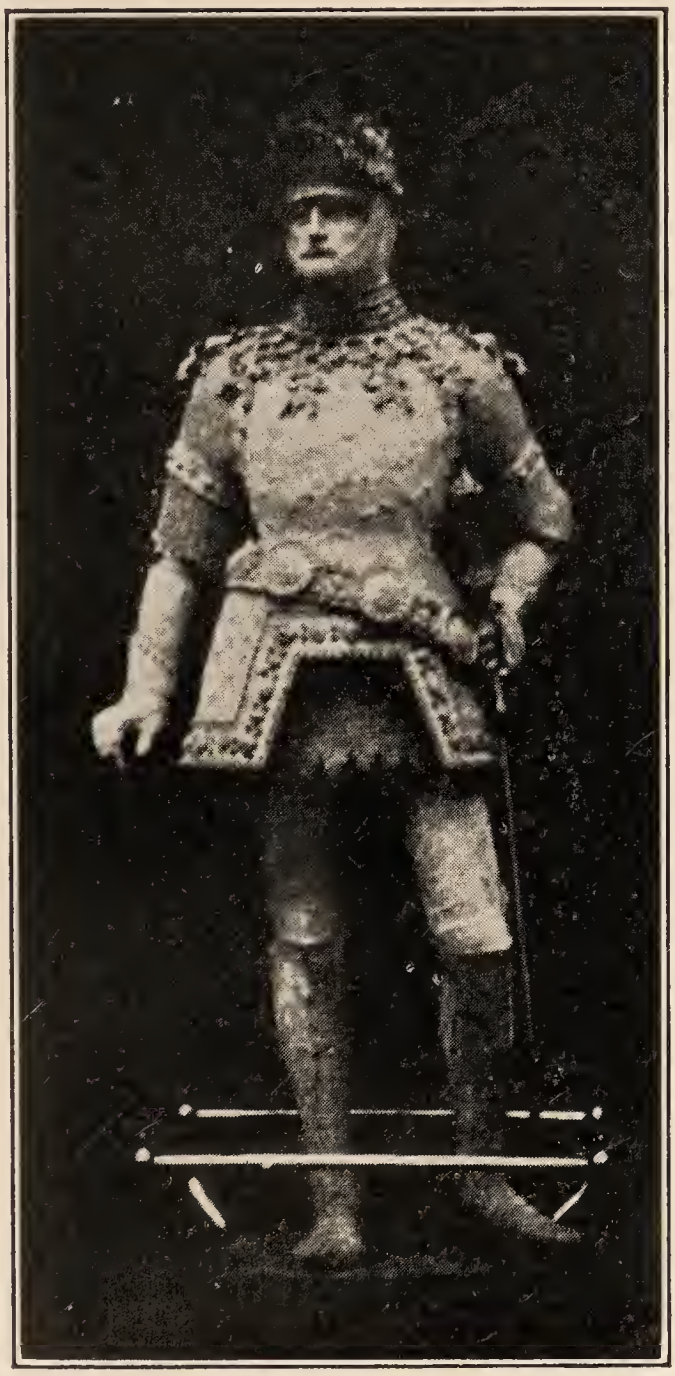


FIG. 193.—Correct posture in art. Richard Coeur de Leon. (*Corcoran Art Gallery.*)



FIG. 194.—Correct posture in art. Pocahontas. (*Jamestown, Virginia.*)

sils, bronchitis, heart disease, clothing too tight across the thorax or "suspender" garters or underbodies dragging down unduly on the shoulders and sedentary habits, producing muscular weakness and atony.

Preventive Measures.

Faulty attitudes will be mentioned more at length, in connection with the aetiology of lateral curvature of the spine, but suffice it to say at this time the more common malpositions assumed by children in sitting is the tendency to lie down in chairs by sitting on the anterior edge, so that the middle and lower portions of the spine are unsupported; this of course tends to round back and stoop shoulders (Figs. 202 to 205). Another evil tendency is that seen at

the school desk which is too low and leads to round shoulders, as the scholar stoopes over or leans on it. Carrying the hands in the trousers pocket is another vicious habit in boys leading to contracture of the chest. Sleeping on the side, with legs drawn up and not on the back without a pillow, tends to stretch and weaken the posterior spinal muscles, besides interfering with the proper expansion of the lungs and development of the respiratory muscles. Slouching in standing and walking, standing on one leg and not bearing the weight equally on both, may increase the tendency to relaxation (Figs. 196, 197, 207 to 209).

It is a common error for mothers of children with weak backs to feel that all of the clothing must depend from the shoulders, which already tend to stoop, instead of relieving them of any weight possible by making the hips do all they can to lessen this drag downwards. If shoulder straps are used to support garments they should be held by a cross strap to bring them as near the neck as possible, so as to have less leverage on the movable shoulder in producing malposition.[1] These common errors are mentioned so that they may be eliminated, as aetiological factors in producing or increasing the deformity.

Treatment consists of a drill in a military attitude with head erect, chin in, chest out, stomach drawn in and feet pointing well forward. A convenient way to teach a child to assume this attitude is to have him stand with his toes about two inches from the edge of a door and have the thorax touch it, but the nose and abdomen are to be held back from it (Figs. 191 and 210). While maintaining this attitude, the patient should daily or twice daily do various exercises and Swedish movements, which are most useful and essential to strengthen the unduly weak muscles in these conditions, such as,

(*a*) Free exercises in extending the arms in turn, upward, outward and downward rapidly and fully. Also backward as in swimming.

(*b*) Lying prone with the head and shoulders over the edge of a table, in the corrected position (Fig. 211).

(*c*) With the hands on the back of the neck, the elbows held well back, with the front of the thighs supported on a box and the feet held, make the patient maintain the trunk in a horizontal position, thus increasing the tone of the superficial and deep groups of back muscles (Fig. 212).

(*d*) Hanging from a bar with the legs flexed on the thighs to 90° and the thighs flexed on the body a like amount, straightens the dorsal kyphosis and lumbar lordosis as well (Fig. 213).

(*e*) Swinging dumb-bells between the legs and upwards as high as possible strengthens all extensors. A variation of this is to grasp a rod or cane with the hands separated a distance equivalent to the width of the shoulders and endeavoring to touch the floor, as nearly as possible, and then extending the spine with the arms carried vertically upwards.

(*f*) For lordosis due to flaccid abdominal muscles, lying on the back raising the legs vertically a number of times is an excellent exercise to increase abdominal muscular tone, when done from 45° and then lower them. This exercise should be done very slowly.

[1] Goldthwait, Trans., Amer. Orthopaedic Association.

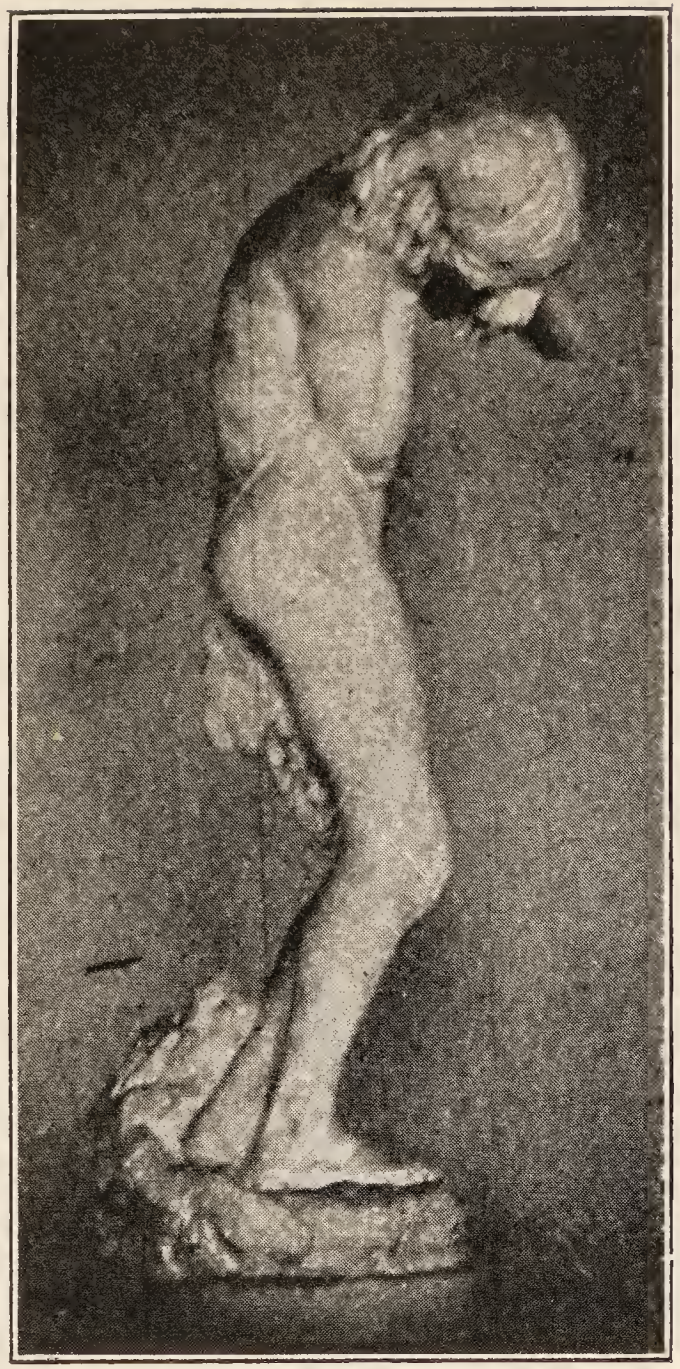


FIG. 195.—Postures indicating shame, evil intent or viciousness are depicted usually by bad physiological attitudes. Ischmael. (*Peabody Gallery, Baltimore.*)

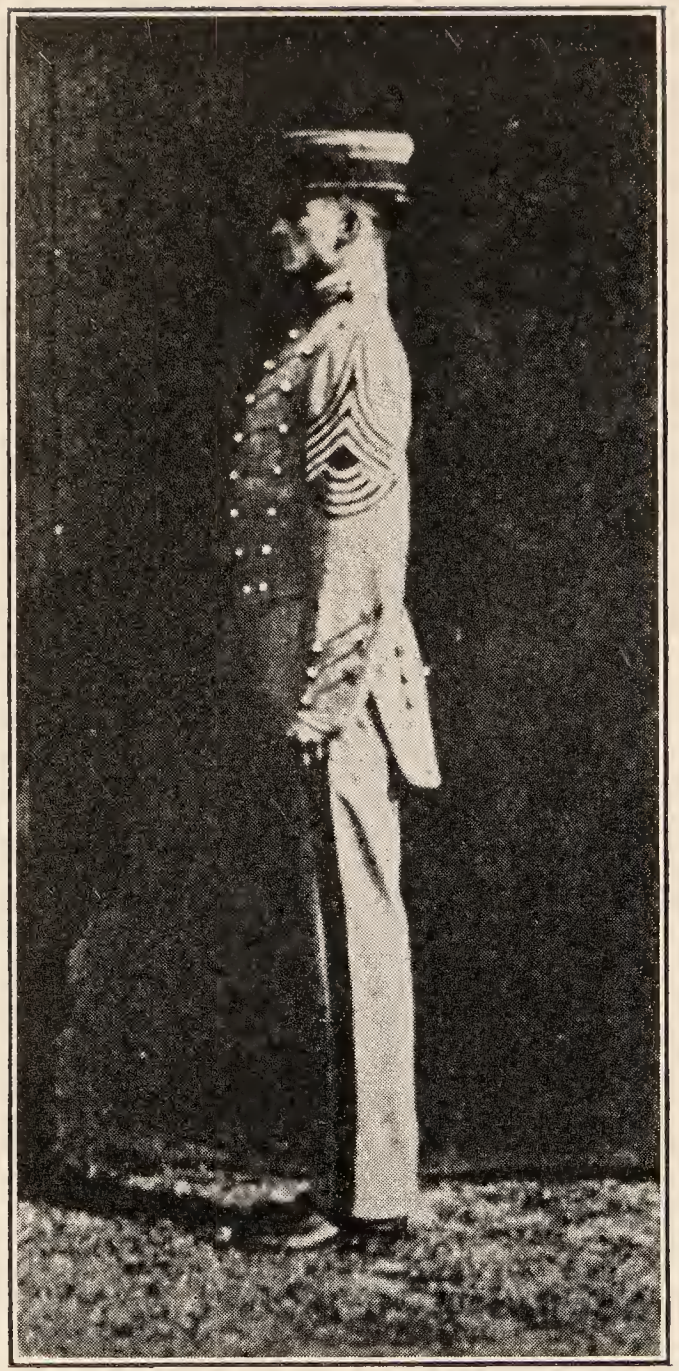


FIG. 196.—Overaction of back muscles tending to produce fatigue and in turn muscle strain.

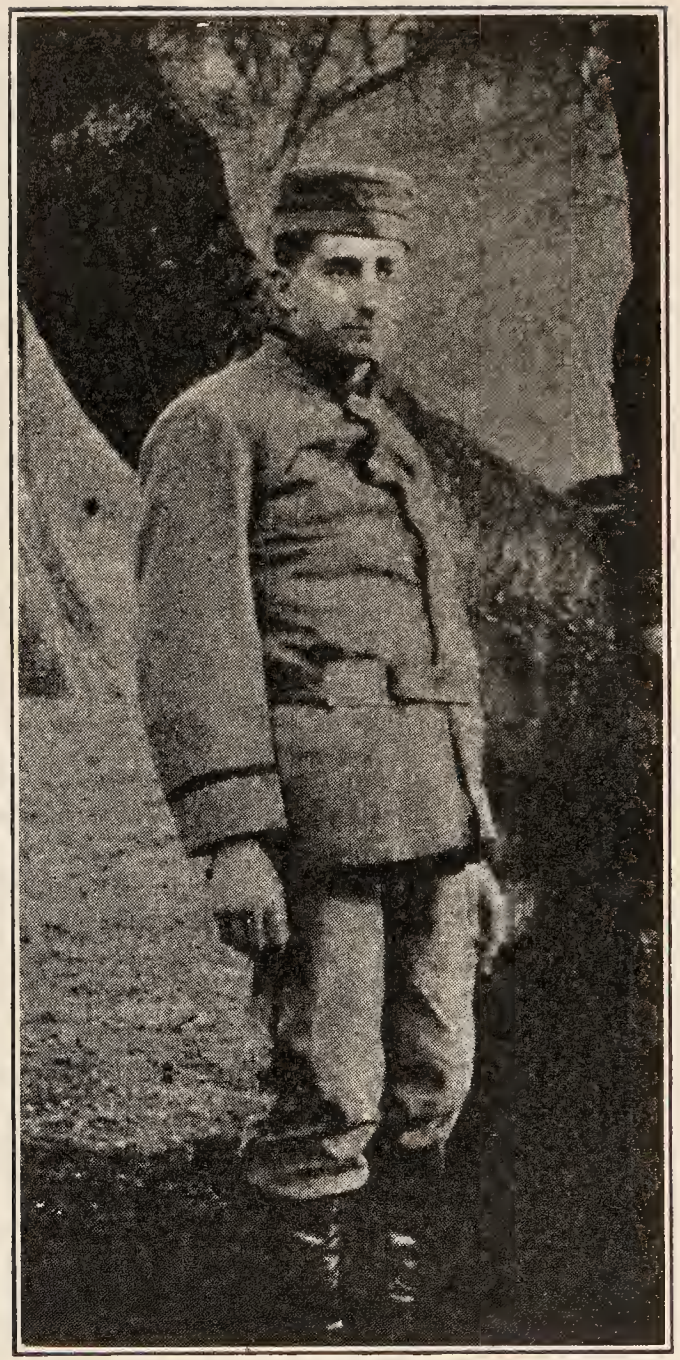


FIG. 197.—A vicious physiological and dejected attitude in a German prisoner.



FIG. 198.—Correct posture indicated in photo-diagram.

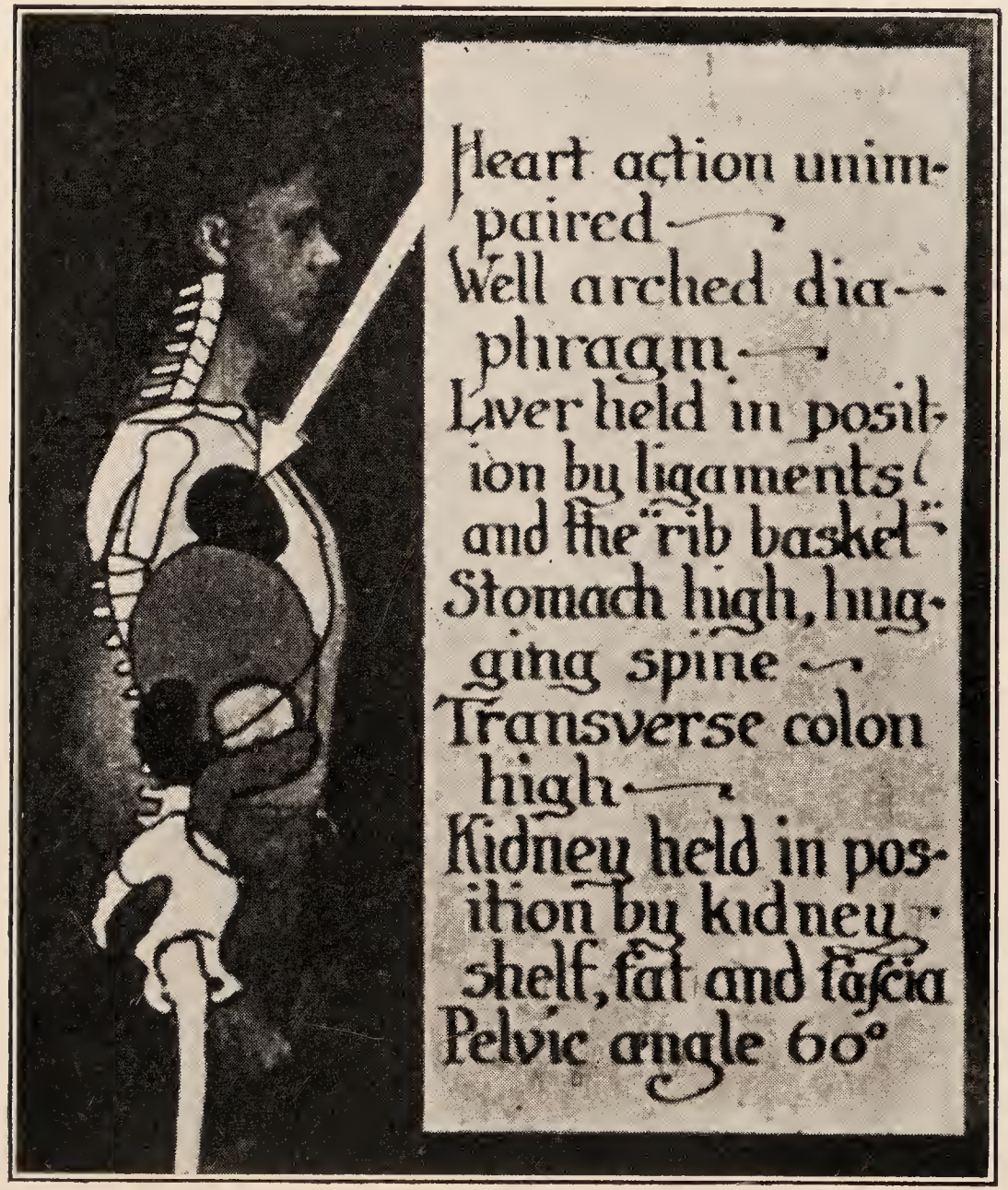


FIG. 199.—Correct posture indicated in photo-diagram.

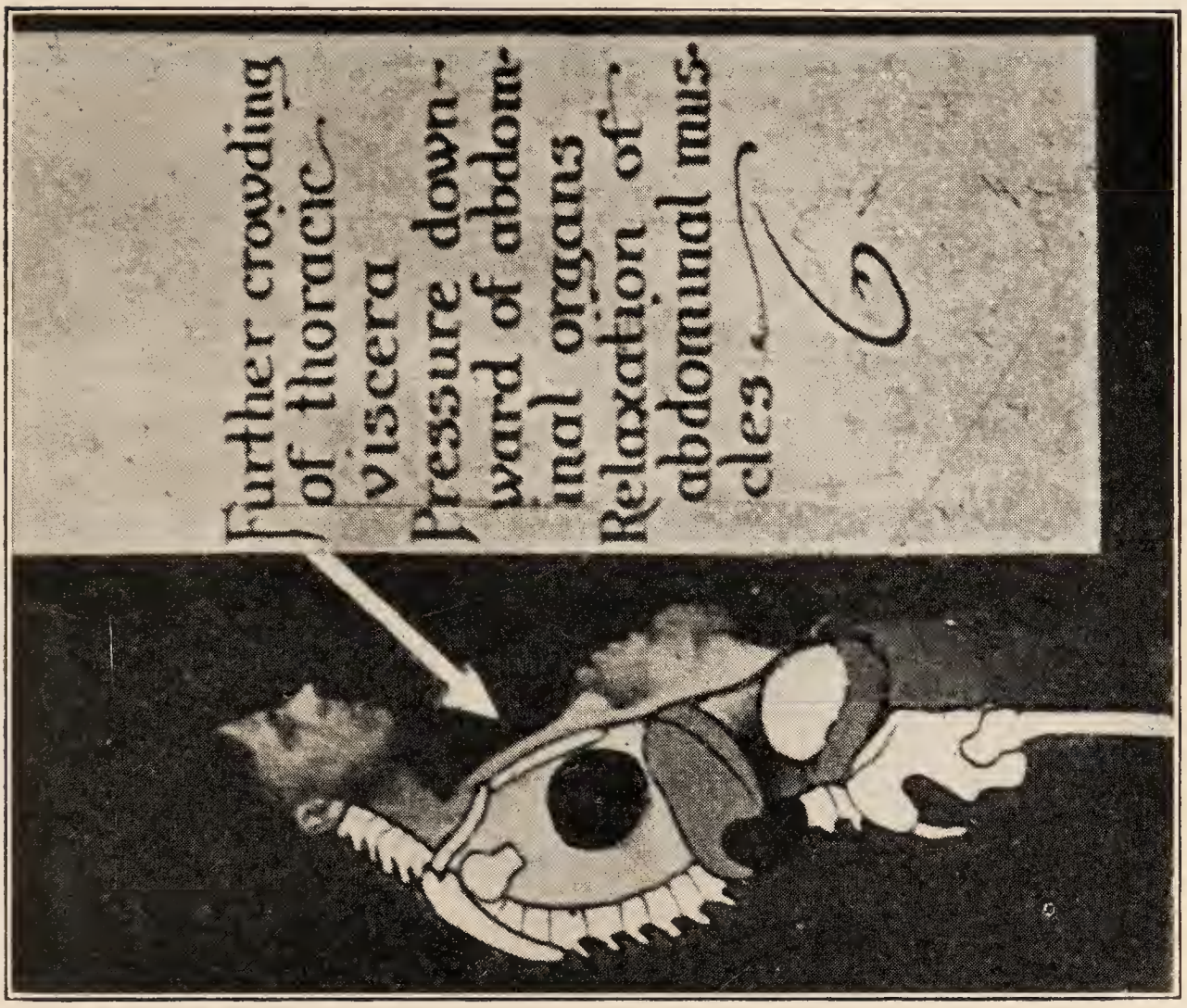


FIG. 201.—The same indicated by photo-diagram. "Round-hollow-back."

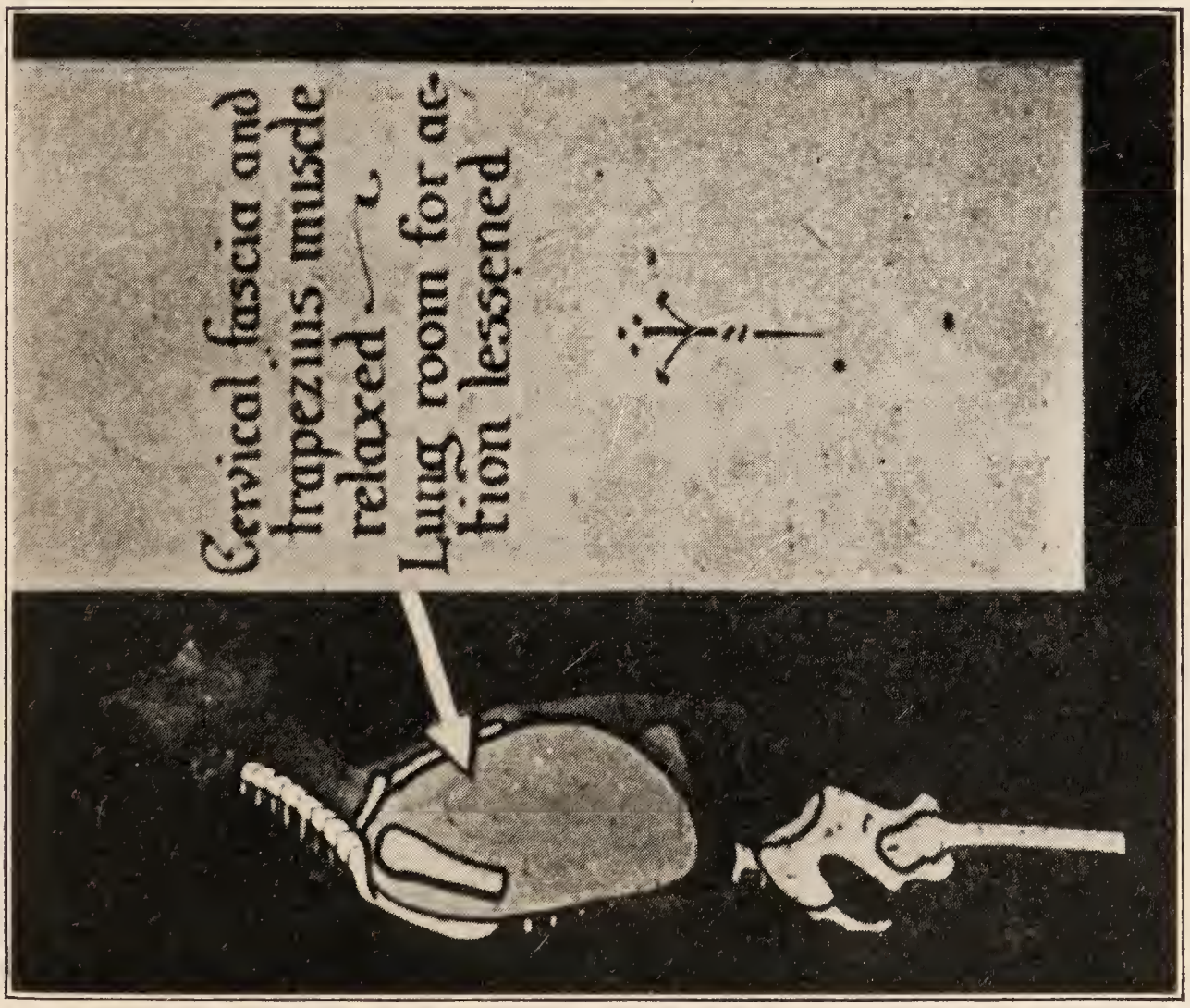


FIG. 200.—Incorrect posture indicated in photo-diagram. "Forward thrusting neck."

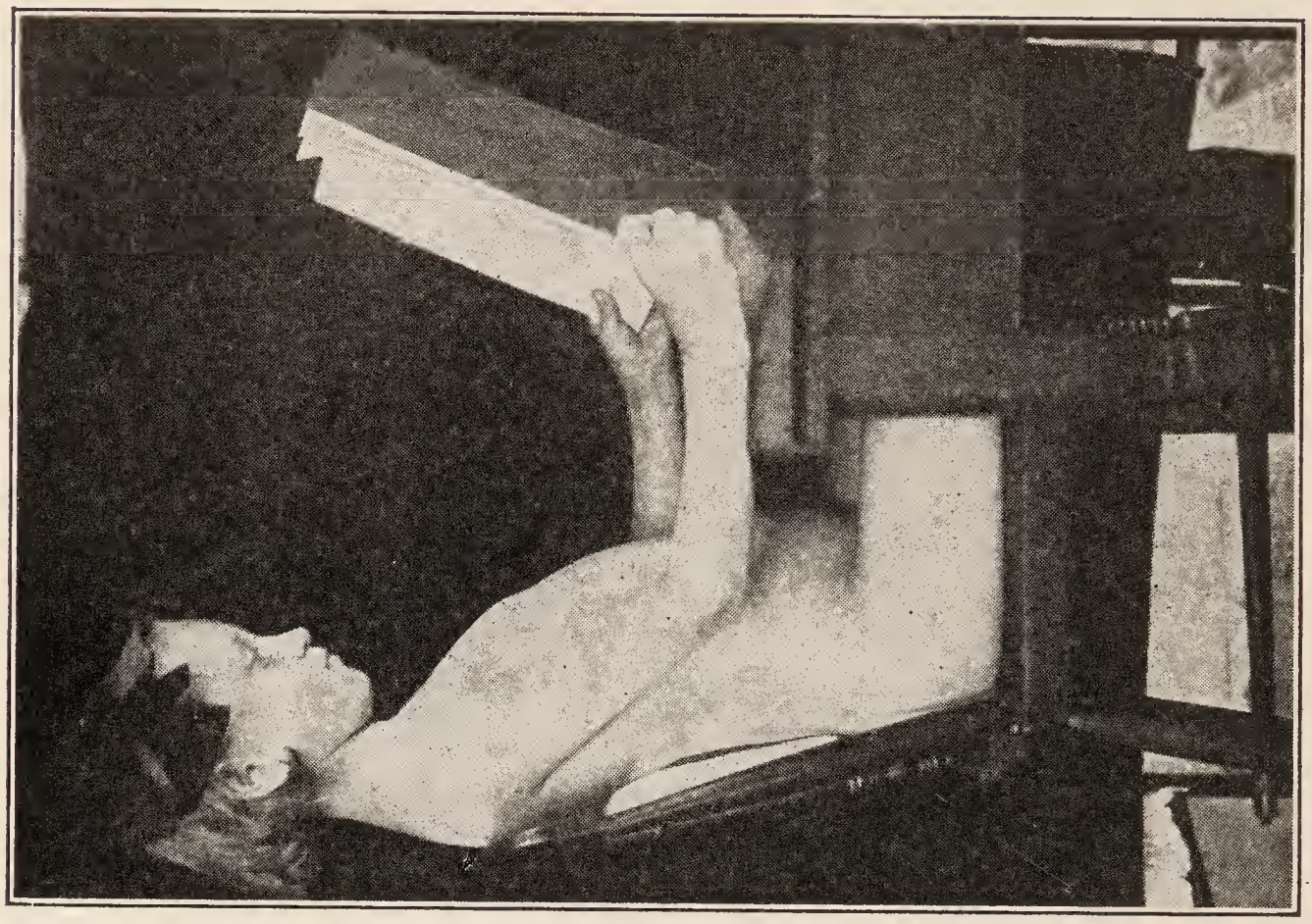


FIG. 203.—The proper sitting position. Pad or cushion in lumbar concavity.



FIG. 202.—One cause of kyphosis, "Lying down in chairs."



FIG. 204.—Detrimental sitting posture.



FIG. 205.—Correct posture at desk.

(*g*) Teaching the child to take the position shown in Fig. 214, known as "prone stride sitting" with the arms in the wing position is very helpful in strengthening the spinal muscles and flattening the back.

(*h*) In Fig. 215 is shown an excellent means of strengthening the posterior shoulder muscles by raising the arms up and down and increasing the effort by suitable dumb-bells held in the patient's hands which are to be raised and lowered in the plane of the shoulders.

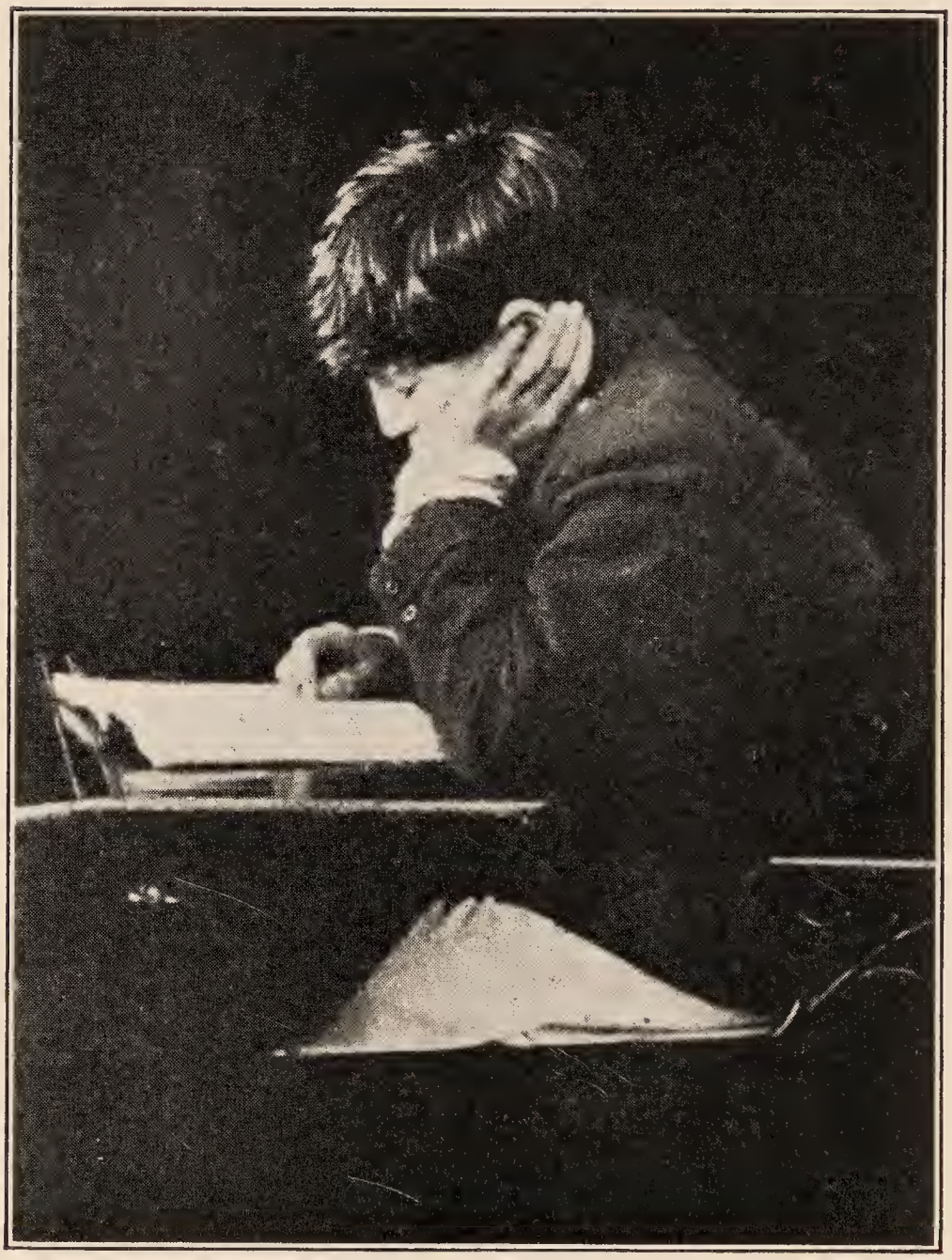


FIG. 206.—Incorrect posture at desk.

(*i*) "Long sitting, wing position" is another useful drill to use daily in overcoming tendencies to round shoulders and swayback (Fig. 216).

(*j*) In very many cases of kyphosis such contraction of the pectorals (major and minor) has occurred from prolonged faulty position, that it is essential to stretch them thoroughly before it is possible for the patient to assume anything like a proper position. One method of doing this is shown in Fig. 217, where the patient is in the "stretch grasp, hook lying" position and the gymnast forcibly carries the extended arms downward and backward. The stretch can be facilitated by having a padded block between the shoulder blades.

Another method to accomplish this is to have the patient hang on the bar or "boom" with the hands as far apart as possible and for the gymnast to exert forcibly forward pressure between the shoulder blades (Fig. 247). Or, have



FIG. 207.—Correct sleeping posture, free elevation of ribs at each inspiration and flat back.



FIG. 208.—Incorrect sleeping posture on side with knees drawn up; "round back."



FIG. 209.—Incorrect posture sleeping on abdomen, lifting whole weight of thorax at each inspiration.



FIG. 210.—Learning the proper standing position. Compare Fig. 191.



FIG. 211.—Strengthening the erector spinae, trapezius and rhomboids.



FIG. 212.—"Prone, leg lying, holding, arms, wing, or rest position."



FIG. 213.—"Hook hanging."

the patient sit and the gymnast place her knee between the scapulae and extend the arms backward.

In some cases we find forcible hyper-extension on the kyphotone for 20 minutes or half an hour helpful in stretching daily these contracted muscles.

An exercise to correct forward thrusting of the head and neck, is "reach, grasp standing, head extension with resistance." In this the patient faces the wall at arm's length with palms against the wall on a level with the shoulders and the head is extended backwards, while the gymnast resists. The chin should be held against the throat when this is done. This exercise is to be repeated again and again.



FIG. 214.—"Prone stride sitting."

In some cases who seem too weak to be able to hold erect, or in children who will not make a voluntary effort to maintain an improved position, a light steel back brace must be used in conjunction with the exercises, but it is better to do without it, if possible. It should be simply a light C. F. Taylor back brace, such as is used in Pott's Disease, with webbing straps instead of an apron, and with a throat strap if the neck is thrust forward (Fig. 218 and 219).

A simple and useful device to accomplish the same purpose is known as a "back-board" and consists of any hard wood board 1½ inches wide, 3/16 thick and sufficiently long to extend from the middle of the neck to the waist. It has two holes one inch from the top for a neck tape and two similar holes

below for the waist tape. About the middle of the scapulae two holes are bored in it on each side for a tape to pass around each shoulder and hold them back.

15. **"Sciatica," Sacro-iliac Strain, Sacro-iliac Subluxation, "Sacralization of the Fifth Lumbar Vertebra, and Hypertrophied Transverse Processes of the Fifth Lumbar Vertebra.**

These have been rather fully discussed as to their symptoms and path-

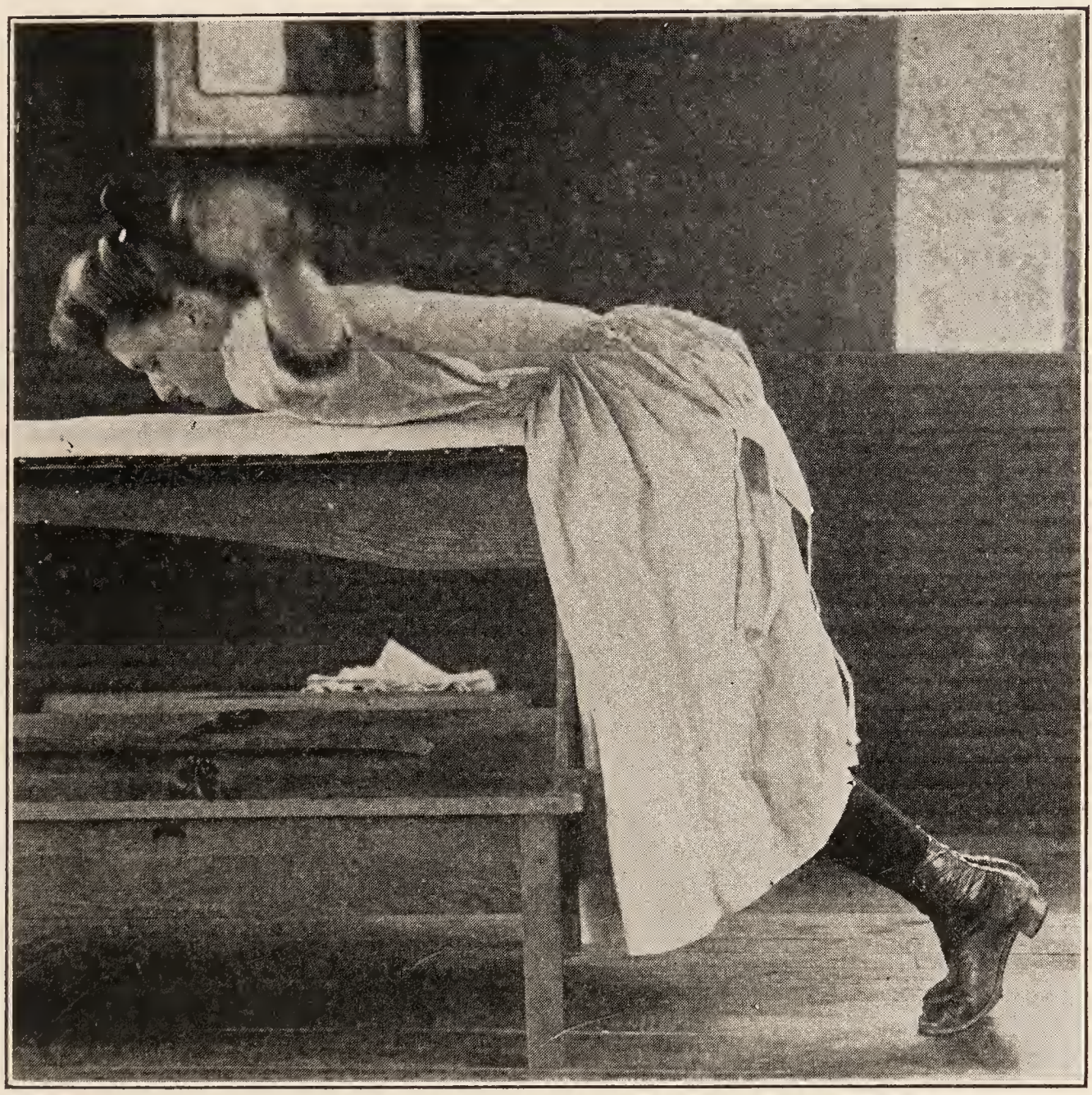


FIG. 215.—An exercise for weak trapezius and rhomboids with dumb-bells.

ology under the Differential Diagnosis of Pott's Disease. However, the following points should also be borne in mind.

It should be recognized that the diameters of the pelvis are dependent upon motion at the middle of the sacrum through the sacro-iliac joints. Thus, if the transverse diameter of the pelvic brim is enlarged, the ilia flare outward and the ischia come closer together below and *vice versa*. Similarly, if the distance from the pubis to the sacrum is increased, the distance from the pubis to the coccyx is diminished and *vice versa*. These are normal motions that are brought into play as a result of the pseudo-arthrosis between the sacrum and the ilia. Of course, there is more motion in these joints in women than in men especially during child-birth and menstruation. Thus, we may regard the



FIG. 216.—An exercise for weak trapezius, weak rhomboids and lordosis.



FIG. 217.—An exercise to stretch contracted pectorals, given forcibly by gymnast with a pad under apex of kyphosis. "Hook-lying."

sacro-iliac joints as true joints and they are subjected to the same injuries and diseases that other joints are. Being imperfect joints, however, they are much more liable to injury. These injuries may occur from long stooping, standing, lying or sitting; the latter especially in chairs that do not support the lumbo-sacral region. In stooping for a prolonged period, the muscles that support the joint become fatigued and the strain is put upon the posterior ligaments, as the upper portion of the sacrum is forced backward. In long standing, similarly, the strain is chiefly downward and forward. It is brought about also in lying on the back on a flat surface, especially under anaesthesia on an



FIG. 218.—Before and during treatment for kypho-lordosis. (Attention is directed to the improved nutrition of patient from better chest expansion and to the use of webbing straps on the brace instead of an "apron.")

operating table, without a pad under the relaxed lumbar spine. Particularly in fat individuals the lumbar spine sags downward and produces ligamentous and articular strain, which may be of long duration, following operative anaesthesia especially in the lithotomy position with assistants leaning heavily against the knees of patient and no pad in the small of her back.

After prolonged osteo-arthritis of the hypertrophic type, fusion may occur between the ilium and sacrum on one side. Thus, the patient is subjected to a loss of the normal physiological motion and strain is put on the opposite side. Since the ham-string muscles are attached to the ischia, it is seen that tension

upon these will cause movement and consequently pain of sacro-iliac strain and it is a valuable point in making a diagnosis. This is often spoken of as Goldthwaite's sign when taken in conjunction with over stretching of the sciatic nerve, which may be traumatized against the subluxated sacro-iliac joint when put on the stretch. With a focal infection elsewhere in the body X-ray findings may show in an old sacro-iliac strain, as a point of least resistance, exostoses from an osteo-arthritic change. The pain is usually over the back of the thigh, calf or here in sacro-iliac strain.



FIG. 219.—Cervico-dorsal "Round Back" before and during treatment, showing effect on the appearance by the brace.

Treatment of Sacro-iliac Strain or Subluxation.—Like other strains or traumatic conditions, the prognosis is much more favorable and a cure may be obtained more speedily, if thorough treatment is instituted as soon after the injury as possible. It will be recalled that the stronger ligaments, which bind the ilium to the sacrum, are on the posterior aspect of these joints. The inner side of the pelvis, over which the roots of the sciatic nerve pass, is normally smooth and not strengthened nor padded by ligamentous tissue to the same degree as the posterior aspect. Thus if the ilium on one side is forced outward and backward the posterior ligaments act as a hinge and two sharp edges of the component bones present themselves as irritants to the nerve roots. Or we may have a condition where lateral compression of the pelvis may rupture or tear these posterior ligaments in whole or in part and open up the

the posterior aspect of the joint with little sciatic nerve irritation, but diffuse pain in the periosteal nerves near the posterior side of the joint. Again we may have a trauma, which forces the iliac portion of the joint forward or backward, rupturing the ligaments and respectively presenting a sharp edge of bone of the ilium or sacrum, as the former or latter occurs, with symptoms of sciatica. Finally we may readily imagine a person stooping forward and straining to lift an unusually heavy object with the legs firmly fixed and braced. If the ligaments at the joint in question tear, on one or both sides, it is easy to understand that



FIG. 220.—The modified C. F. Taylor brace for round shoulders and forward thrusting neck.

the sacrum will be forced forward and its sharp anterior edge will produce nerve pain.

Often the history of the case and the clinical aspects will point out the best mode of procedure in treatment. Unfortunately the X-ray rarely shows wide separation or the position of the component bones in this joint, as the slipping or subluxation is slight and not in any relative proportion to the intensity of the pain, even when viewed with the stereoscope.

Fixation, uninterrupted, continuous and prolonged until union of the torn ligaments is firm, is essential and close approximation of the ligamentous fila-

ments is greatly facilitated by utilizing superimposed pads of felt over the joint to express bruised clots of blood, serum, fibrin and so forth. Next to the skin should be a piece of felt 1 by 3 by ¼ of an inch, then on that piece 2 by 3½ by ¼ and then one of 3 by 4 by ¼. This felt wedge is most important in securing relief of pain and promoting cure. It is held in place by three or four overlapping strips of Z-O Adhesive, 2½ to 3 inches wide applied with the greatest possible tension from just in front of the anterior superior spine around the back to a corresponding point on the other side, leaving the abdomen free.

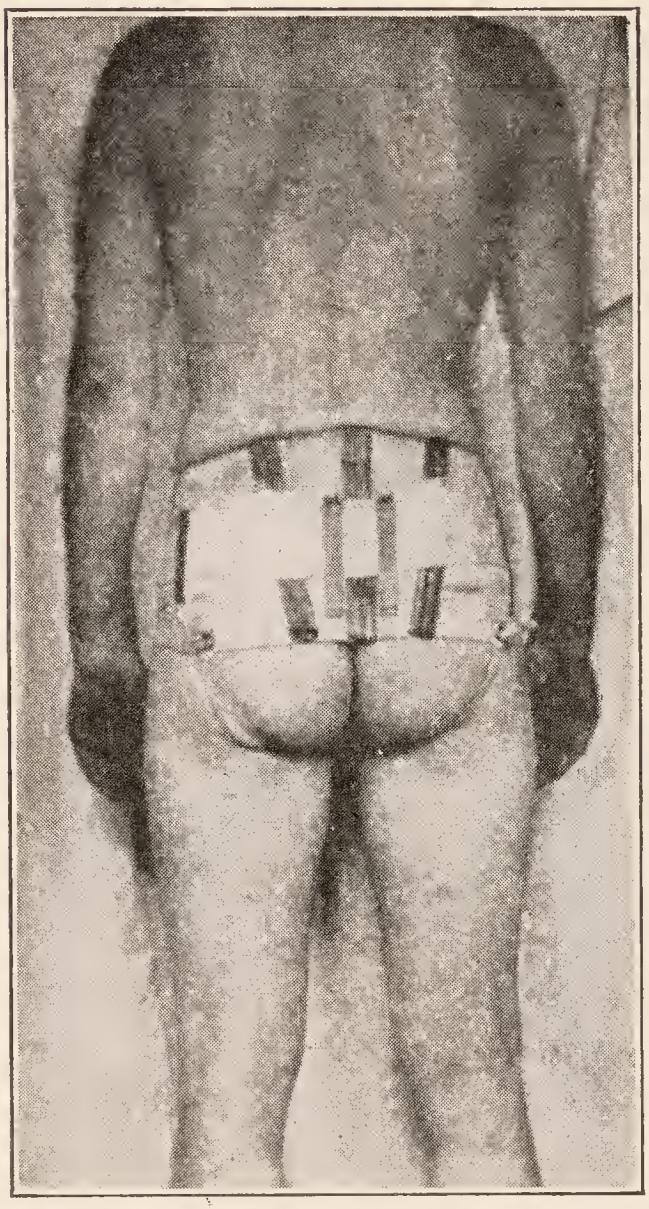


FIG. 221.—Belt for sacro-iliac strain. (See text for details.)

This remedy will be found of great service in the majority of early cases, but cannot be continued too long on account of the skin irritation produced by the surgeon's plaster. It is needless to say that, that type of subluxation in which the ligaments are not torn, but act as a hinge with the anterior portion of the joint separated, will not be helped by this, as in that condition strapping should go across the abdomen to hold the anterior superior spines closer together, but such a condition is infrequently met with.

When, in the judgment of the surgeon, some alternative must be used instead of the adhesive plaster, two methods are open, either a plaster of paris jacket, well padded as described, and put on in prone recumbency on a hammock or a "Sacro-iliac Belt" must be used (Fig. 221).

This belt is laced on and consists of elastic rubber stockinet reinforced with whale bones or steels in gussets like a corset and *with a leather and felt pad over the joint* and on the outside further tightened by two or three wide circular non-elastic webbing straps extending from the crest of ilium above to below the symphysis.

In the most acute cases it may be necessary to secure firm fixation by one of the methods named and put the patient to bed on a firm surgical bed with Buck's extension and an inclined plane to afford relief of pain in the affected leg.

The duration of treatment is from two months as a minimum, to six months or more, depending on how long after injury proper treatment is instituted and how severe the initial trauma was. Of course focal infection in a tooth, tonsil, sinus and so forth finds ready response at a point of least resistance in the injured sacro-iliac joint and proper steps must be taken to remove this cumulative cause of trouble, which will show itself as an osteo-arthritic change by hypertrophic points near the injured joint. It is needless to say salicylates, aspirin and opiates have no curative value in these conditions, whatsoever.

16. **Torticollis or Wry-neck.**

This affection may be a congenital deformity or it may be acquired and if the latter, is acute, sub-acute or chronic. The head leans towards the shoulder on the affected side and the face is rotated towards the opposite side. It is characterized by an habitual contracture of the Sterno-cleido-mastoid on one side in most cases, at times associated with the adjacent Trapezius muscle. In the most chronic severe forms due to bone lesions the Platysma, Scaleni and Splenius or even all the muscles of the neck may be involved.

Frequently in the chronic form the face and jaw are asymmetrical being atrophied on the affected side and even the shape of the skull may be changed from the continuous muscular pull or spasm. The same resultant changes in bones may be found by X-rays of the cervical spine as a result of Wolff's Law causing osteoschlerosis on the concave side of the twisted neck and osteoporosis on the convex. It is to be distinguished from Stiff Neck or Myalgia, due to cold or draught. The sudden onset, explainable etiology, acute character, intense pain and tenderness and ready response to heat and massage of this condition clear up the diagnosis of this transient affection. The varieties of torticollis with the pathology of each will be taken up seriatim.



FIG. 222.—Contracture of left sterno-cleido-mastoid producing torticollis.

1. **Congential Torticollis,** in its true sense, is that variety due to deficiency of liquor amnii or asymmetry of cervical vertebrae, malposition of the foetus in utero or attachment between the skin of the face and amnion in early embryological life. Rare instances record a familial tendency. Boys and girls are equally prone to it and there is no marked difference in the frequency of the two sides (Figs. 222, 223 and 224).

2. **Traumatic Torticollis,** often confused with congenital, in that it is brought about by twists of the neck, rupture of the sterno-cleido-mastoid or violence from forceps, pressure or manipulation during birth, is more properly to be termed Obstetrical than Congenital. In many instances haematoma have been found in the torn muscle. If the condition persists fibrosis ensues and the muscle becomes hard and unyielding, losing its elasticity and contractibility.

3. **Spasmodic Torticollis,** may be choreiform in character or appear as a Tic Giratoire of Trousseau, a habit spasm. This variety is usually found in older patients and dependent on some central lesion or the peripheral irritation of the Spinal Accessory Nerve from glandular, bone, ligamentous or muscle inflammation, or possibly focal infection.

4. **Paralytic Torticollis,** may be of central origin in conditions such as Anterior Poliomyelitis or caused by peripheral nerve lesions, where contracture occurs on the opposite or normal side, from unopposed muscular action.



FIG. 223.—The same after operation wearing Goldthwait's collar.



FIG. 224.—The same cured.

5. **Compensatory Torticollis,** is seen in bad cases of Scoliosis, where we have a severe dorsal curvature below in the opposite direction and is also met with in cases of unequal eyesight in the two eyes, the so-called "Torticollis Oculaire," uncorrected by prisms or tenotomy.

6. **Cicatricial Torticollis,** from burns, skin lesions, new growths and tubercular glandular scars form a group.

7. **Osseous Torticollis,** from tubercular osteitis of the Atlas and Axis manifests itself as a wry-neck of marked degree accompanied by a general muscle spasm of all the superficial and deep groups of muscles and is readily identified by a history of slow, gradual progressive onset, a tubercular diathesis and a clear X-ray. Protection fron jar by holding the head with the hands is charac-

teristic. Closely allied to this is sub-acute and chronic cervical osteo-arthritis showing in the X-ray new bone formation, as peripheral osteophytes, periosteal roughenings, cloudy irregular articulations, etc., from a focal infection in a tooth, tonsil, etc. This variety presents much less acute symptoms than the Tubercular variety and the pain is of a dull annoying subacute type.

Diagnosis.—A close study of the *variety* of torticollis is essential in order that the proper treatment may be instituted for the condition is apparent at a glance.

Prognosis.—The outlook for the correction of this deformity depends largely upon its duration and variety. Cases of long standing yield much less readily to treatment, owing to fibrous changes in muscles and the *physiological changes in the bones* to meet new functional requirements.

Treatment.—When the variety is determined, the causative condition is to be removed, so far as is possible.

In the congenital form and traumatic variety, involving chiefly the sterno-cleido-mastoid, treatment should be instituted at once to overcome the malposition of the infant's head. This can be best accomplished by recumbency and head traction, the latter with the spreader-cord placed eccentrically or by adhesives over gauze applied to the head, face or forehead to pull laterally to shoulder, waist or side of the bed as the surgeon's ingenuity and the degree of deformity may require.

Operative Treatment.—Later, if the deformity persists or nothing has been done, early myotomy of both the sternal and clavicular attachments of the sterno-cleido-mastoid should be done, as soon as the infant's or child's vigor justifies.

Under a general anaesthetic, a transverse incision is made half an inch above the sterno-clavicular articulation, great care being observed to avoid the anterior jugular vein. By blunt dissection the fascia, platysma and muscle sheath are separated, a grooved director is passed under the muscle and its fibres divided cautiously by the scalpel. Great caution should be observed to avoid overzealousness by dividing the posterior part of the muscle sheath on account of the underlying large vessels, but one should rest content in dividing the true muscle tissue, which can be made more tense and more easily cut by the assistant holding the head in as corrected a position as possible. A subcuticular suture of number 2 chromic cat-gut should be put in, and the wound closed and covered with several layers of silver foil and ample gauze. Over glazed cotton or stockinet a light helmet and body cast is made of plaster of paris to hold the head in relation to the shoulders in an *overcorrected posiiion* for six weeks, in a position correcting both lateral leaning and rotation. When the cast is removed, massage and passive stretching should be given daily for several months to prevent a recontraction (Fig. 169).

In some instances it is necessary to utilize a brace similar to the author's brace used in Cervical Pott's Disease for a time (Fig. 161).

In infantile paralysis involving the neck muscles such a brace may have to be worn habitually.

In the spasmodic variety a brace often is a cruel restraint, as the patient tugs against it, as a horse does against a tight check-rein. In such cases resec-

tion of a portion of the spinal accessory nerve is necessary. The point of election for the incision is the upper part of the middle third of the posterior border of the sterno-cleido-mastoid from two to three inches in length. After incision of the skin and fascia, the head is flexed forward the muscle relaxed and retracted forward, disclosing the nerve. A portion of the nerve should then be resected. The wound is then closed in the manner described for myotomy of the sterno-cleido-mastoid.

In serious involvement of the Trapezius and deeper lying spinal muscles, operative relief is rarely undertaken, as involving too extensive an undertaking and stretching is best accomplished by head traction.

The Finney Operation for Spasmodic Torticollis.

In a paper presented before the American Orthopaedic Association on May 2, 1922, Doctor J. M. T. Finney stated that but little was known as to the etiology and pathology of this condition; medicinal treatment and physiotherapy availed little and myotomy was of doubtful value. As both sides were usually involved, nothing short of nerve resection of the posterior branches of the first, second and third cervical motor nerve roots produced real results.

He said, "In order the better to understand the rationale of the operation about to be described, we will give a brief review of the anatomy of the region.

"The muscles which interest us are the platysma, sterno-cleido-mastoid, trapezius, splenius, semi-spinalis-capitis, or complexus as it is sometimes called, rectus posticus, major and minor, obliquus superior and inferior and the levator anguli scapulae. The platysma depresses the mandible, has some power in flexion of the head, and by its attachment to the orbicularis oris pulls laterally the corner of the mouth. Its nerve supply is from the inframandibular branch of the facial.

"The sterno-cleido-mastoid on one side rotates the chin in the opposite direction, elevates it and draws the occiput toward the shoulder of the same side. The spinal accessory and first two cervical nerves supply it with motor fibres. Authorities still disagree as to the ultimate action of this muscle under certain conditions.

"The cervical portion of the trapezius draws the occiput back and flexes the head laterally, when acting only on one side. Its innervation corresponds to the sterno-cleido-mastoid with the addition of occasional fibres from the third cervical.

"The splenius is a rotator and an extensor and lateral flexor of the head, receiving fibres from the first four cervical roots.

"The complexus extends the head, flexes it laterally and has the same nerve supply as the splenius.

"The rectus posticus, major and minor, are powerful extensors, and the obliquus-inferior the most important rotator. This latter muscle develops a very powerful leverage due to its insertion into the transverse process of the axis. It is supplied by the first cervical or suboccipital nerve exclusively.

"The levator anguli scapulae is supplied by the third and fifth cervical nerves. Russell working on monkeys in Horsley's laboratory and under his direction in an interesting experimental study determined the nerve supply

of the muscles involved in wry-neck by electrical stimulation of the cervical nerve roots. He gives the following table of the muscles represented by the first four cervical roots:

Supplied by the first cervical nerve, posterior root, rectus major and minor, obliquus superior and inferior, trapezius, sternomastoid, omohyoid, infrahyoids and sometimes complexus.

By the second complexus, splenius, trapezius, sternomastoid, infrahyoids and omohyoids.

By the third complexus, splenius, trapezius, sometimes sternomastoid and levator anguli scapulae.

By the fourth, Complexus, splenius, cervicalis ascendens, longus colli, levator anguli scapulae.

"The operation about to be described is based upon the anatomical relations as observed in operations performed upon our series of 27 cases and in the dissecting-room findings in approximately 50 cadavers. After having tried various positions, we now employ that known as the cerebellar position, the patient lying prone with the shoulders elevated, the head slightly flexed and projecting over the end of the operating-table and supported on a rest. The usual aseptic technique is employed.

"The incision should be made along the posterior border of the sternomastoid muscle, beginning at a point about two fingers' breadth below the level of the angle of the jaw and continuing upwards, along the edge of the muscle to a point about the level of the lobe of the ear, then curving over toward the mid-line to a point about two fingers' breadth below the occipital protuberance, thence carried across the mid-line following the same general direction as just described in reverse order. When completed, the incision would be in the form of an inverted "U." Reflect back a flap of skin and subcutaneous tissue, taking care to identify and avoid the lesser occipital nerve which is quite superficial and lies along the posterior border of the sternomastoid muscle, in its upper half. Having exposed and identified this nerve, follow it down to the point where it emerges from behind the posterior border of the sternomastoid muscle. At this point, the spinal accessory can be located and recognized by its intimate association with this nerve and by retracting the sternomastoid muscle, the anterior divisions of the second, third and fourth cervical nerves now come into view, together with the chain of deep cervical lymph nodes. A little further in front of the plexus, and consequently a little deeper in the wound, will be found the trunk of the spinal accessory where it emerges from the body of the muscle. The nerve having now been definitely identified, can be resected at any point desired. If care is exercised in the dissection the sensory branches running to the scalp need not be injured. Division of these nerves gives rise to numbness and disturbed sensation. Search should next be made for the great occipital nerve where it emerges through the fibres of the splenius about 1 cm. from the mid-line, and just below the skin incision. Having identified this nerve, divide transversely at this point the trapezius and splenius muscles, exposing the fibres of the complexus, which is easily recognized. The fibres of this muscle are divided in turn throughout its whole thickness, in the same plane as the skin incision, and it is then reflected backward in the same way, care

being taken all the while to preserve the great occipital nerve which lies immediately beneath it. This exposes the two recti-muscles, major and minor and the superior and inferior oblique each of which can be distinguished by the direction of its fibres and their common point of origin. The trunk of the great occipital nerve should then be traced down to the point where it emerges from the vertebral foramen at the lower border of the inferior oblique muscle. At this point will be found its anastomosis with the sub-occipital nerve running across the body of the muscle to the point where it is given off from the first cervical nerve in the sub-occipital triangle.

"The great occipital nerve should be resected below the point of anastomosis with the sub-occipital. The latter can then be traced out in the sub-occipital triangle as it emerges between the vertebral artery lying deeply in the triangle and the upper border of the inferior oblique muscle. Its branches to the recti-muscles and the superior and inferior oblique muscles are given off here, and the main trunk of the nerve can readily be resected at this point. Care should be exercised not to injure the vertebral artery, which may be identified as it lies on the floor of the triangle. The splenius and complexus muscles should be reflected sufficiently to allow of the exposure of the third cervical nerve, where it emerges a finger's breadth below the great occipital. At the level of the second and third cervical nerves is located a venous plexus of considerable size which may give rise to troublesome bleeding if care is not taken to avoid or control it, which, however, can be readily done. The third cervical should be resected where it emerges from the vertebral foramen as it supplies fibres to the overlying muscles (splenius, complexus and trapezius). After the trunk of the three upper cervical nerves have been resected as described, the muscles may be replaced layer by layer, and held in place by a few stitches, and the wound closed in the usual manner. In our earlier operations we excised portions of these muscles, but subsequent experience has shown that with complete resection of the nerve supply, this rather mutilating procedure may be omitted. We have always inserted a drain consisting of a small piece of gauze at each corner of the incision.

"From our experience with our group of cases, we are convinced that the probable reason for failure to get cures is failure to get the nerves. We feel convinced, too, that it is impossible to get satisfactory exposure and identification of the nerves sought for by any less extensive incision than that described.

"Formerly we applied a plaster of paris bandage reinforced with wooden splints, with the head in an over-corrected position, but this added greatly to the patient's discomfort and appeared to be rather a source of irritation than a help and so was discontinued in favor of the ordinary gauze dressing and soft bandage, reinforced with light wooden coaptation splints if desired. Notwithstanding the great extent of the wound, the healing has been uniformly satisfactory and the resulting disability surprisingly slight.

"The average time of the operation, doing two sides at one sitting, is 1½ hours. We would emphasize the fact that this operation should not be undertaken by any but an experienced surgeon, and only after thoroughly familiarizing himself with the anatomy of the part, as the sucess of the operation

is dependent largely upon careful dissection and recognition of the different structures sought for.

"Prognosis.—Chiene says the prospect of a permanent cure of this affection by any method is in inverse proportion to the severity of the spasm, extent of the muscles affected and duration of the disease.

"Starr gives a guarded prognosis, but distinctly pessimistic.

"These two opinions reflect very faithfully that held by physicians and surgeons alike, since no treatment up to the present time has given uniformly satisfactory results. Of our series of 27 operated cases, 2 have not been heard from recently. Of the remaining 25, 3 are unimproved, 15 have been improved, but not entirely relieved, while 7 have been completely cured. It should be borne in mind that these operations cover a period of more than 20 years, that the earlier operations were very incomplete, and that the operation just described has been developed only recently. It has been used in only a few cases, too few and too recent to enable us to pass final judgment as to its merits, but sufficient, as compared with previously used and less radical methods to justify its more extended use."

CHAPTER XVI

LATERAL CURVATURE OF THE SPINE

Lateral Curvature of the Spine.

Definition.—Lateral curvature is a deviation of a portion of or the entire spinal column to one or the other side or both sides of the vertical plane of the body, which usually causes more or less rotation of the vertebrae from which the ribs, transverse processes and muscles of one side may project backwards more than the other. One shoulder or one hip is commonly more prominent than the other.

Synonyms.—Scoliosis and rotary lateral curvature.

Varieties.—I. Congenital is seen; from (1) Foetal rickets (rare). (2) Unequal development of the two sides of the thorax or inequality in the length of the legs or height of pelvic brim or "numerical variation" of the vertebrae.[1]

II. Acquired, being the commoner of the two and the one usually understood, from (1) Debility. (2) Faulty attitudes. (3) Empyema. (4) Paralysis. (5) Distortion of the pelvis as sequela of rickets. (6) Rachitic changes in the spine itself. (7) Distortion of the pelvis from asymmetrical muscular pull. (8) Physiological transformation to meet pathological function.

The occurrence is chiefly during the growing years. The age, when the cases are presented for treatment, is usually from the eighth to the fifteenth year.

Fifty per cent. of the cases occur in the period from the first to the twelfth year approximately.

Forty per cent. of the cases occur in the period from the twelfth to the fifteenth year.

Ten per cent. of the cases occur in the period from the fifteenth year upwards.

Frequency.—It occurs to a slight extent in a large number of individuals unrecognized; of deformities it forms from 20 to 30 per cent.

Sex.—Four girls to every boy is about the proportion in which it is seen. Boys have nothing like the attention paid to their figures that girls do, hence they are less frequently brought to the surgeon's care for this trouble, unless the deformity is quite marked, and therefore statistics may be faulty on this point. Girls are more liable to form sedentary habits, taking less exercise and growing more rapidly than boys.

Stages of this Affection.

There are three stages of lateral curvature.

I. **Initial Stage.**—This stage is not as a rule seen by the surgeon, as the deformity is not discovered by the parents until about the time of puberty.

[1] Dwight, Rosenberg and Bohm. (vide infra.)

It occurs earlier, but is not recognized. Often the dressmaker will comment on the inequality of the two sides in waist or skirt or both. The slightest elevation of one shoulder or prominence of one hip is first noted and the patient seems to bear more weight on one side habitually in sitting or standing than on the other. Inclination of the trunk to one side may be seen. Unequal muscular strength on the two sides is not the rule, although apparent from the child standing habitually on one leg (Fig. 225).

II. The Stage of Development is that in which the surgeon is usually consulted for the marked distortion, which has taken place as (1) a flexible or (2) fixed curvature.

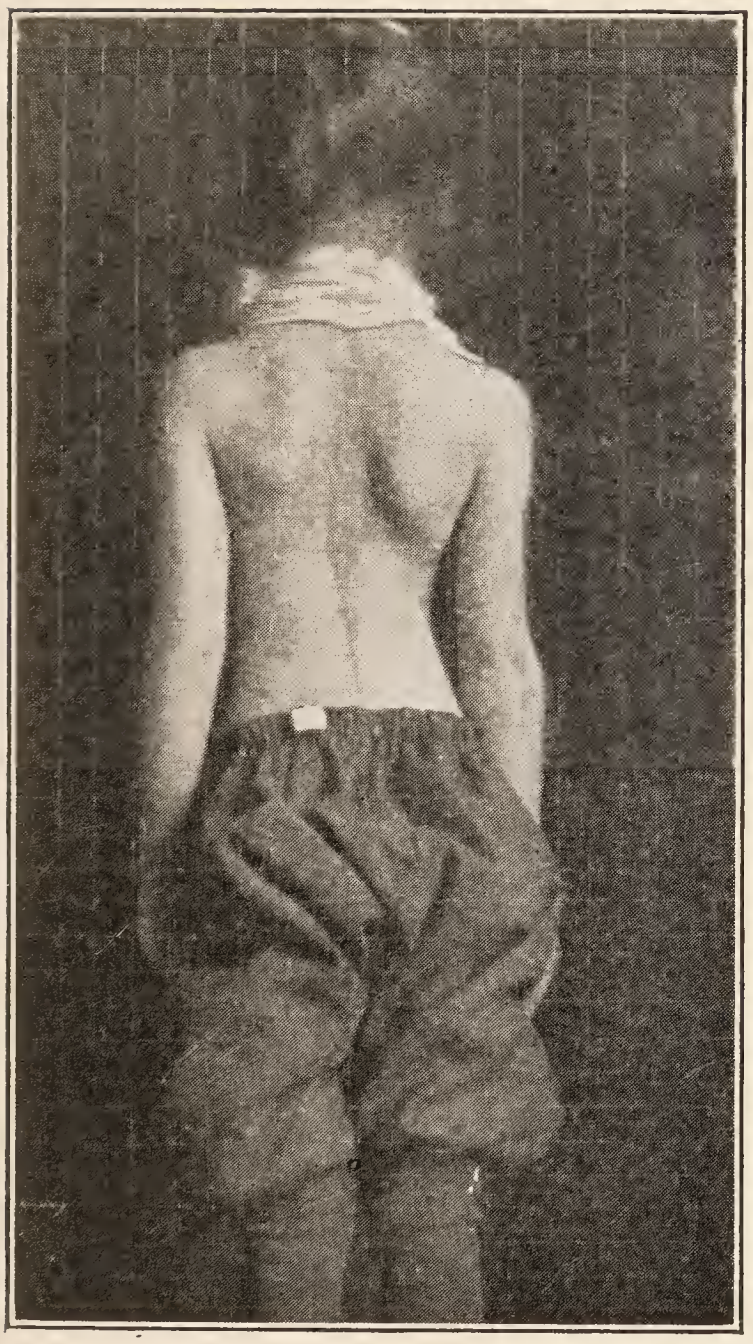


FIG. 225.—A beginning left dorso-lumbar "*C*" flexible curvature. Note the dropping and "angel-wing" right scapula.

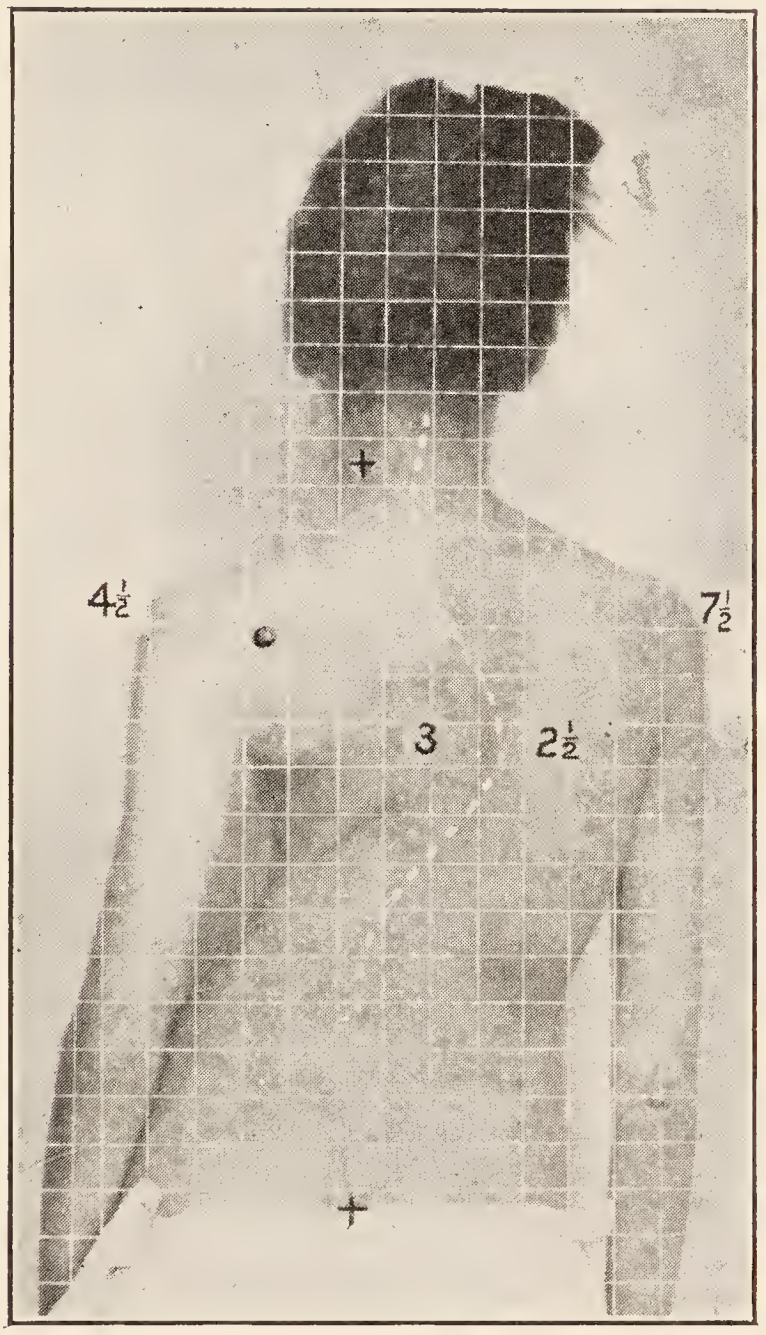


FIG. 226.—A right dorsal and left lumbar "*S*" fixed curvature made through 1′ wire mesh screen. XX equals vertical axis. Numerals indicate distances from axis.

A "flexible curvature" disappears on suspension or recumbency, as it is due to muscular or ligamentous relaxation, while a fixed curvature due to bony metamorphosis does not. A "flexible curvature" may be voluntarily corrected by the patient when taught to stand straight. A "fixed curvature" is sometimes called a "structural curvature," implying permanent bony change (Fig. 226).

In the majority of cases the muscular system is poorly developed.

Nothing is complained of but the deformity, which varies greatly in the progress it has made. In growing girls we may find fatigue in standing or walking, perhaps neurasthenic pains in the back, legs or chest.

III. The Stage of Arrest cannot be sharply separated from the second stage, but it is usually considered as reached, when the time of osseous development is completed.

Symptoms.

Symptoms are Not the Rule in This Affection.—I. Pain may be present, but it is not proportionate to the deformity; if present, is usually in the lumbar region and thighs and worse from fatigue, as "backache."

Pain may be due to: (1) muscular or ligamentous strain. (2) Pressure from distorted ribs or change in the shape of the thorax with displacement of viscera, thoracic or abdominal (enteroptosis). (3) Neurasthenia and lowered vitality from lack of exercise. In severe disease in the debilitated, pain as a paraesthesia or hyperaesthesia, neuralgia, etc., may be complained of.

II. Interference with the functions of the stomach, liver and intestines in severe cases is rare. Gastroptosis with fermentative dyspepsia is at times a troublesome complication.

III. Dyspnoea may be present and is common in severe cases.

IV. Asthenia is seen in the worst types of the affection. In the worst form of this affection that came under the author's observation the patient could only lie down to sleep when a corrective jacket was worn, from interference with the heart's action, due to stenosis of the aorta, with mitral and tricuspid incompetency, following the curvature.

V. Limping is caused in severe cases by tilting of the pelvis upward secondarily, making one leg shorter than the other, but this is extremely rare.

VI. Subcutaneous fat is markedly diminished often in severe cases, owing to general impairment of the respiratory and other bodily functions.

Physical Signs.

The Physical Signs on the Other Hand are Marked.—The deformity is the lateral leaning or twisting of the spine. The deformity in mild cases may cause no signs in a casual examination save the prominence of the hip on one side and the elevation of the shoulder on the other, which causes a sensitiveness often unwarranted in a patient, as the condition is not generally recognized. Compensatory curves may or may not be above or below the primary curve, or both, leading to "single," "total," "C" or double "S"-shaped curves. Prominence of the hip is due to rotation of the ribs forward on that side and the leaning of the whole trunk to the opposite side. A simple "C" curvature may involve the entire dorsal and lumbar regions as a curvature to the right (or left) with rotation backward of the ribs on the same side, which is usually the right (Fig. 227).

Primary cervical or high-dorsal curves are rare except with torticollis; when present there is a long compensatory curve in the opposite direction below. The head is held toward the concave side and the shoulder of the convex side is elevated and the opposite shoulder seems longer on the concave side.

Dorsal curvature is commonly convex to the right. In these cases usually the right shoulder is raised, the right scapula is on a higher plane horizontally than the left, and is pulled further away from the spinal column. The left

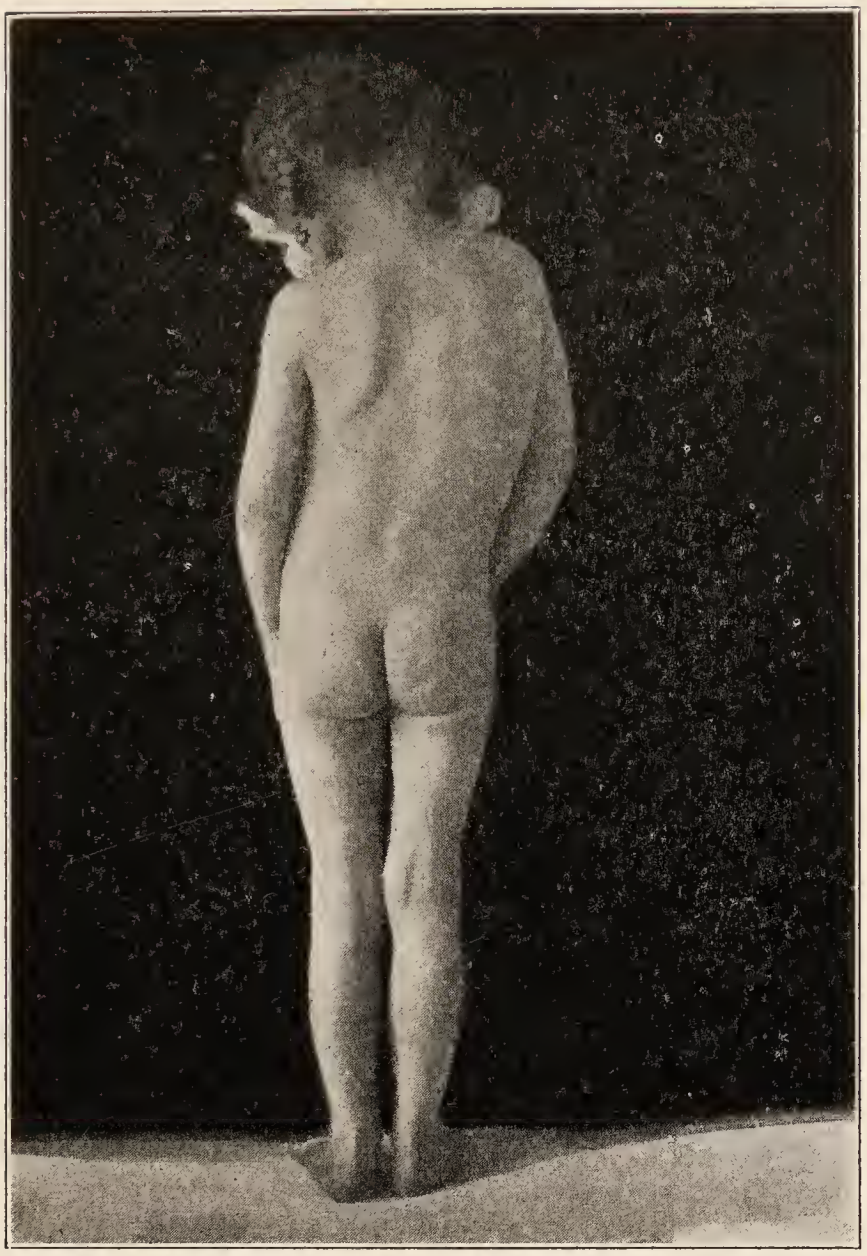


FIG. 227.—Attitude in lateral curvature from pleuropneumonia. (*Young.*)

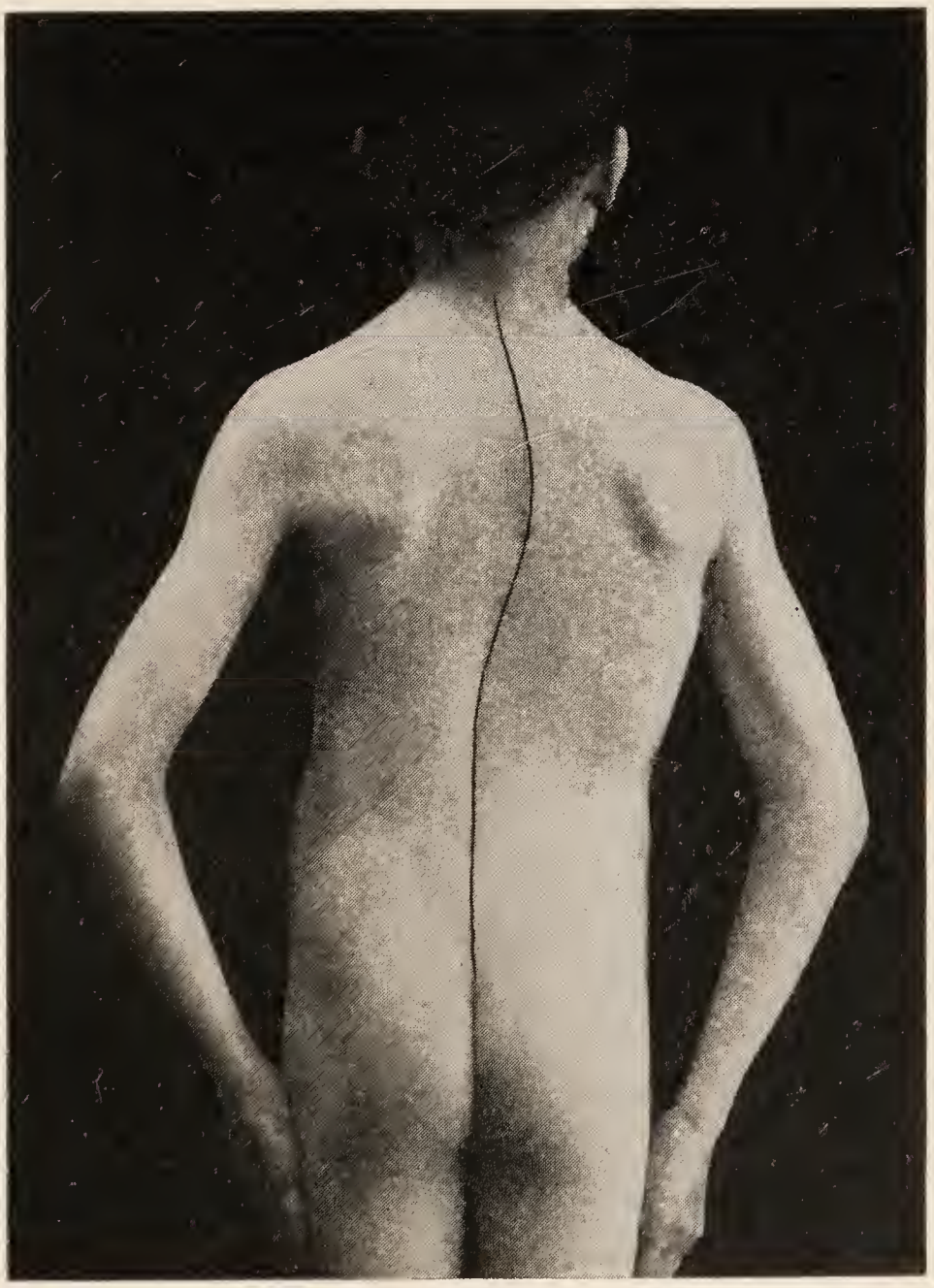


FIG. 228.—Primary right dorsal scoliosis. (*Young.*)



FIG. 229.—Primary left dorsal scoliosis. (*Young.*)

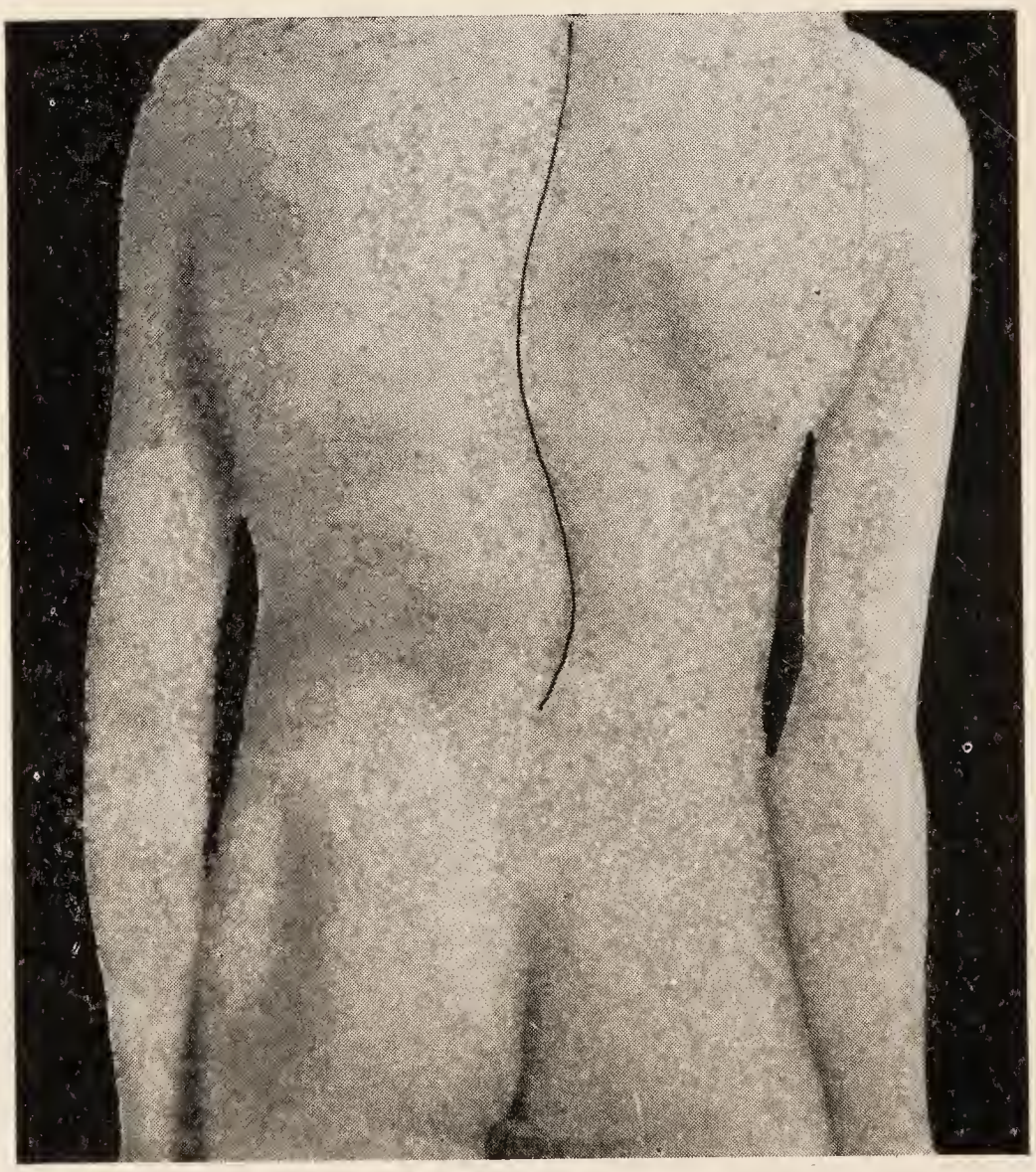


FIG. 230.—Primary right lumbar scoliosis. (*Young.*)

shoulder is lowered and the scapula approaches nearer the median line. The thorax below the left scapula is flattened or hollowed, while the right side of the back is rounded, from the rotation backwards of the ribs on the latter side and forwards on the former.

In the Left Dorsal Curve the Reverse Takes Place.—In front, in well marked cases of right convex dorsal curvature, the left breast is more prominent than the right, owing to rotation of the ribs and falling of the shoulder. The whole trunk may lean to the right, and the right arm swing free from the side and

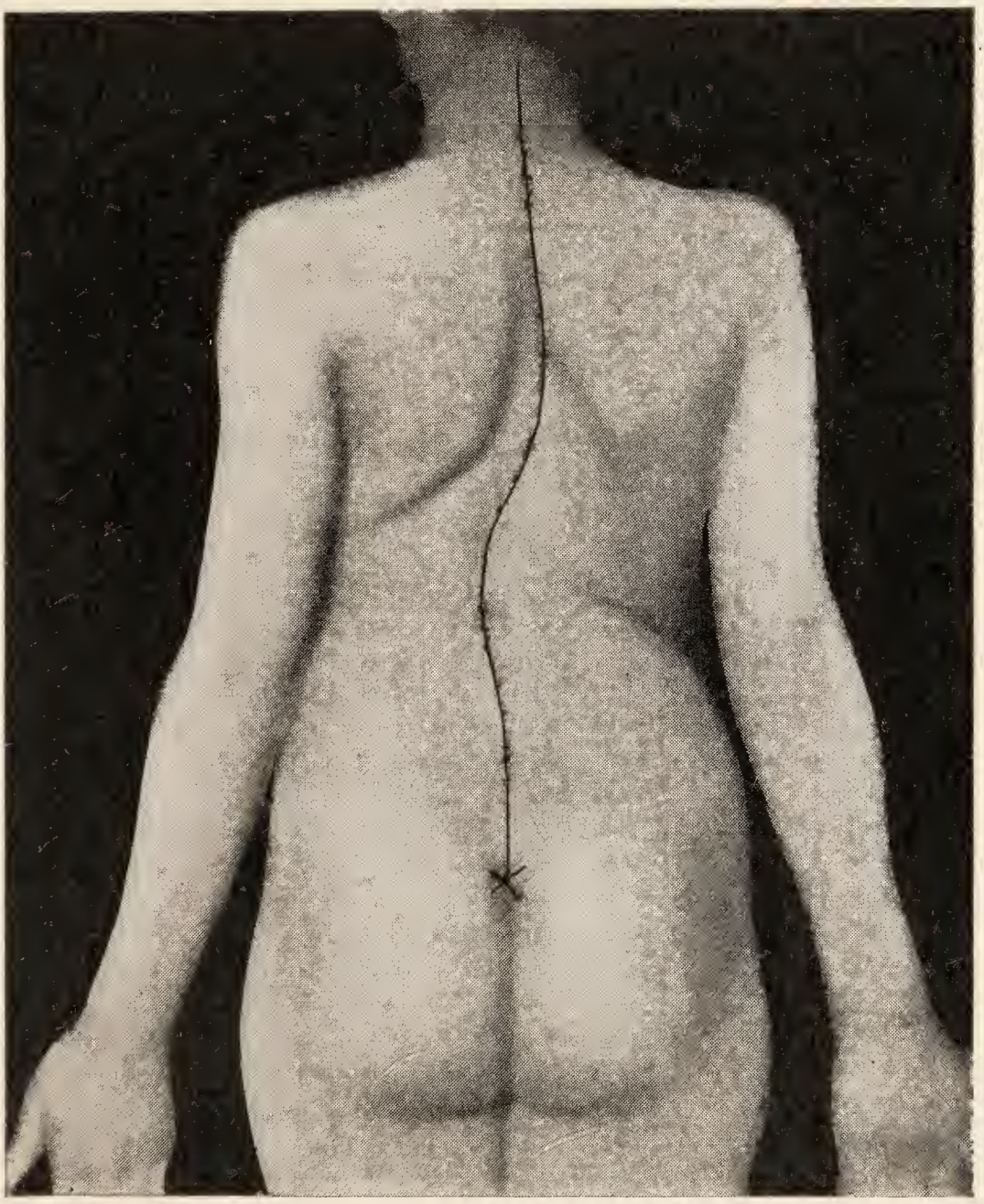


FIG. 231.—Primary left lumbar scoliosis. (*Young.*)

the left hang down against the pelvis. The contour of the back is asymmetrical, the right side is rounded with a hollow above the pelvis, while the left is flattened and sunken above and rounded in the lumbar region with a prominent hip on that side, i.e., "long waisted on the left side," as the patient expresses it. These minor changes in the contour of the hips and shoulders, however, depend on the location of the spinal curvature; a low dorsal being very different from a high dorsal in its effect, for a low right dorsal may give a high left shoulder from a compensatory left cervico-dorsal curve.

Lumbar curvature gives a prominence of the hip (as a rule in double curvature) on the convex side of the dorsal curve. Similarly in a long lumbar curve simply, we may find the prominent hip on the concave side of the lumbar curve. But few cases are exactly similar in their physical appearance. The rotation

backward of the transverse processes in the lumbar region occurs over the, or on the side of the, convexity, which is usually the left; in these cases, the umbilicus is to the right of the medial line. The contour of the back is, therefore, as in dorsal curvature, full or rounded over the convex side and flattened or hollowed over the concave side.

It is impossible to separate low dorsal and lumbar curvatures as the resulting deformity is the same, but the distortion of the more pronounced curve predominates.

A "double curvature" is one where two curves with their resulting distortions are equal. In it the leaning to one side is not marked as in a simple dorsal curvature (Figs. 228 to 231).

Rotation or Torsion.—In order for a curvature in the spine to occur laterally, a certain amount of rotation or torsion of the vertebrae on themselves *must take place*. The amount of this is the guide to the severity of the case as it results in a twisting of the ribs (through their attachments to the transverse processes), and as the ribs rotate backward they lift the scapula of that side causing elevation of a shoulder and *vice versa;* lower down this vertebral twist causes prominence of the transverse processes with the lumbar muscles, but of course not to the same degree as that seen in the region of the ribs. Torsion may be the first sign noted even before any deviation of the line in the spinous processes is seen, as they may rotate around a line joining the spinous processes as an axis.

Seat of the Distortion.

Authorities differ as to whether lumbar or dorsal scoliosis is the more common, but the "prominent shoulder blade" (in dorsal curvature) is usually responsible for the parent seeking advice of the surgeon, hence our statistics would indicate dorsal as the more frequent.

Approximately three-fourths of the cases seen have one chief curve; over half of these cases are in the dorsal region and are convex to the right; about one-third of the cases have a double curve, and two-thirds of these cases have the upper curve to the right and the lower curve to the left.

Left lateral dorsal curve is commoner in flexible young children.

Varieties Depending on the Cause.

1. Caries in the early stages of Pott's Disease as pointed out under that subject may lead to scoliosis from breaking down of one side of one or more vertebral bodies.

2. Caries with irregular ossification in old neglected healed cases of Pott's Disease may produce scoliosis.

3. Spondylolisthesis with dislocation or fracture of the vertebrae may cause a lateral curvature.

4. Torticollis and Sacro-Iliac Disease or Strain may lead to a postural form of the affection.

5. Rickets may lead to a scoliotic curve, although it is not as common as the rachitic kyphosis. When present is usually to the left. About 10 per cent. of the rachitic have it. Usually in more than half of the cases it appears in

the first six months of life, but may be overlooked and discovered when the child begins to grow more rapidly from the eighth to the fifteenth year.

It may be present without any other signs of rickets and is of equal frequency in boys and girls. Lateral curvature may lead to an antero-posterior curve from the unequal distribution of weight with marked kyphosis above, the lordosis below.

6. The Static form occurs from congenital, traumatic or pathological inequality in the length of the legs or the shape of the pelvis in about one-fourth of the cases seen, and of these the majority have the left leg the shorter. This shortening may be due to infantile paralysis, knock-knee, hip disease, flat-foot, habitual unequal muscular pull, etc. (Fig. 249).

Simple habitual faulty attitude in standing on one leg or leaning to one side is supposed to cause a variety of scoliosis.

Lowered vitality with organic changes in the tissues associated with faulty attitude may cause backache and pain in the onset of lateral curvature.

7. Unilateral Paralysis of the back muscles due to infantile paralysis, or progressive muscular atrophy, etc., may cause the patient to assume a position which will cause the least possible strain to the muscles and result in scoliosis, with the convexity *towards the paralyzed or non-resisting side*, from contraction of those in which the tone is still good on the other side (Fig. 269). Friedrich's ataxia is also frequently accompanied by scoliosis as a symptom as well as by club-foot.

8. Empyema may cause connective tissue contraction, loss of expansibility of the lung on the diseased side and increased expansion of the other, which pulls the vertebrae *over or convex to the healthy side.* Loss of a rib or ribs after Estlander's operation may cause scoliosis. It is not a true scoliosis, however, but may lead to a true lateral curvature with rotation from the altered position and function of the spine (functional pathogenesis of deformity) (Fig. 227).

In all these cases of atelectasis the ribs are lowered on the diseased side.

9. Pneumonia and phthisis are rarely a cause. An heredity of lateral curvature with an heredity of phthisis may lead to a rapid deformity without phthisis. An hereditary predisposition to scoliosis or some form of spinal curvature is found in from one-fourth to one-half of the cases.

10. Sarcoma of the lungs and ribs has been reported as an aetiological factor.

11. Occupation is not as common a cause as would seem, as the laborious occupations are entered upon after ossific hardening has occurred. Examples of it, however, are found in *school children* (hence the play on the word, "scholiosis"), clerks, blacksmiths, hod and basket carriers. Infants may develop scoliosis from one sided nursing by hemiplegic mothers, according to Bradford and Lovett.

The curvature of course depends on the character of the occupation.

12. Unequal eyesight may lead to it from an habitual vicious attitude, chiefly seen as a torticollis or cervical curvature with compensatory curves below. This defective carriage of the head has been called attention to by George Gould and Augustus Wilson, and glasses should not be fitted by oculists except with the head held straight.

13. "Sciatica" may cause a lumbar curve and is seen in early sacro-iliac strain.

14. A "physiological" lateral curve is sometimes seen in righthanded people. Lefthanded people may have a left high shoulder.

Theories as to the Aetiology of Scoliosis.

1. **Unequal Muscular Action.**—By some this is considered the same mechanical condition that is seen in torticollis, but this is questioned by others, as there is no spasm on the concave side of the scoliosis. Many think a weakened condition of the muscles on the convex side is the cause, but in opposition to this is the fact that lateral curvature is seen in the strongly muscled occasionally. In delicate people habits of attitude may weaken certain muscles by over-stretching and this is also seen in the paralytics. However, muscular weakness may be considered a predisposing influence if not an actual cause of the deformity. The muscles, primarily involved, it is supposed by some are the deep group of the erector spinae muscles, i.e., those attached from segment to segment ("intrinsic spinal muscles," Shaffer).

Mackenzie[1] first called attention to the male type of pelvis on one side and the female type on the other in scoliosis with unequal muscular pull.

Riely[2] then pointed out that there is a congenital or acquired rachitic distortion in the crests of the ilia in a large number of cases, so that there is a greater pull on the ribs by the abdominal muscles on one side than on the other and this causes not only the scoliosis but the rotation. The pelvis on one side is of the male type and on the other of the female type. He has also stated that the ilium on one side is tilted not only downward and outward, but downward and forward more than its mate, so that measurements taken from the anterior iliac spines to determine the length of the legs give erroneous results.

It is an error he claims to attribute scoliosis to defective action of the deep group of dorsal muscles with their insufficient leverage on the transverse and spinous processes and that the superficial groups are chiefly concerned with shoulder and arm movements.

He feels that the *abdominal muscles pulling on those long levers*, the ribs, asymmetrically from a distorted pelvis, may not only effect a torsion of the vertebrae, but a lateral deviation as well.

Now whether, as Riely seems to think, an asymmetrical pelvis, is the primary cause or whether an habitual faulty attitude, as the author feels[3] distorts the pelvis and throws the abdominal muscles into one sided action and the spine out of equilibrium, one cannot say. We do know and have seen pathologically in cases of unilateral coxa vara, and congenital hip dislocation, how the pelves are distorted by abnormal and asymmetrical muscular pull, and we must bear in mind that the ossification between the ilium, ischium and pubes by means of the Y-cartilage does not begin until the thirteenth or fourteenth year and is not complete until the twenty-fifth year. The ilium could be pulled in or out as the case may be by an habitual tension of the muscles in one direction. The harm is done usually before the thirteenth or fourteenth year, as the cases are presented for treatment usually at or before that time.

[1] Trans., Amer. Ortho. Assoc., 1894, vol. vii, page 343.

[2] Jour. Amer. Med. Assoc., Apr. 2, 1904.

[3] Amer. Jour. Ortho. Surg., Jan., 1905.

2. **Unilateral Hypertrophy and Atrophy of Vertebrae.**—(Volkmann-Hueter.) Asymmetrical osseous development, as is seen in genu valgum, or ligamentous changes with early ossification of one side, some hold is the cause and not the effect of the vicious attitude. This, however, cannot be proven clinically or pathologically.

3. **Functional Pathogenesis of Deformity.**—Wolff proves "functional use" in the changed or deformed position is responsible for the pathogenesis of the bone deformity and osteosclerosis results on the concave side and osteoporosis on the convex and this is probably the correct view of the *resulting* changes in the vertebrae seen in the fixed curvatures.

Superincumbent weight, pressing on a faulty position of the vertebral column, is the theory that receives the widest acceptance, causing perverted or what we may call pathological function, which leads to bone change. This begins to act in childhood as a vicious attitude with at first a flexible spine, which later becomes fixed from the adaptive shortening of muscles and ligaments, and results in changes in the shape of the bony structures from the pressure of superincumbent weight, as claimed by those who do not hold Wolff's views, and physiological bone transformation to meet pathological static demands by those who agree with him.

4. **Numerical Variations.**—Max Böhm,[1] in a very interesting anatomical, röntgenological and clinical research, has shown conclusively that a large number of cases of so-called "habitual scoliosis," or those supposed to be due to vicious habit, can be traced back to defective asymmetrical embryological development of the vertebrae or ribs of the atavistic (or lower species) type or the epigonistic (or higher species) type.

Dwight[2] called attention to the "Numerical Variations" in the human spine by which is meant "variations in a cranial direction," where the ribs begin to be attached to the seventh cervical vertebra instead of the first dorsal or the ilium is attached to the fifth lumbar vertebra instead of to the first sacral, or where the first dorsal articular processes resemble the cervical processes or the first lumbar the dorsal or first sacral the lumbar, etc., and "variations in the caudal direction" would be the reverse of these in a downward direction.

Böhm having the advantage of the study of Dwight's anatomical collection of 54 spines, that showed these variations, together with X-ray pictures of a series of cases of scoliosis showing these variations also *asymmetrically*, put two and two together very ingeniously and states that the cause of scoliosis in very many of these cases which we see in the developing second decade of life date back to an *embryological defect.* Thus he showed, for example, in X-rays, a partial development of a sixth lumbar or transitional sacral vertebra on the right side with a higher attachment of the ilium of the left side, and consequent left lumbar scoliosis; an imperfect articulation between dorsal and lumbar vertebra on *one* side and consequent sag or curvature of that side; unilateral cervical or lumbar ribs with consequent lateral concavity to the opposite side, etc. It is quite possible as he points out to imagine and recognize one or several of these variations in one individual producing compensatory or structural S-curves.

[1] Boston Med. and Surg. Jour., vol. cliv, No. 4, page 99, and vol. clv, No. 21, page 598.

[2] Memoirs of the Boston Society of Natural History, 1901, vol. v.

One can but praise the logic of Böhm's reasoning and the value of his work and actual demonstrations; at the same time we must bear in mind, certainly in the less severe structural cases, that physiological bone transformation *can* take place as the result of persistent faulty positions, so that we *may get* from this cause also a distinct "variation," not congenital, from the characteristic type of a certain vertebral group. This may be said especially with regard to the articular processes and bodies. Further in viewing radiographs, *unless this is done stereoscopically*, one may fall into errors in judging the shape of rotated vertebrae or whether a rib is seen on the flat or edgewise. The rotation which is always present in these cases causes distortions in *flat* outlines which are confusing.

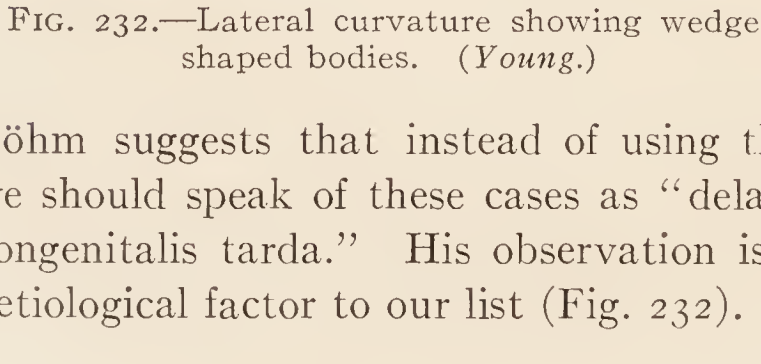


FIG. 232.—Lateral curvature showing wedge-shaped bodies. (*Young.*)

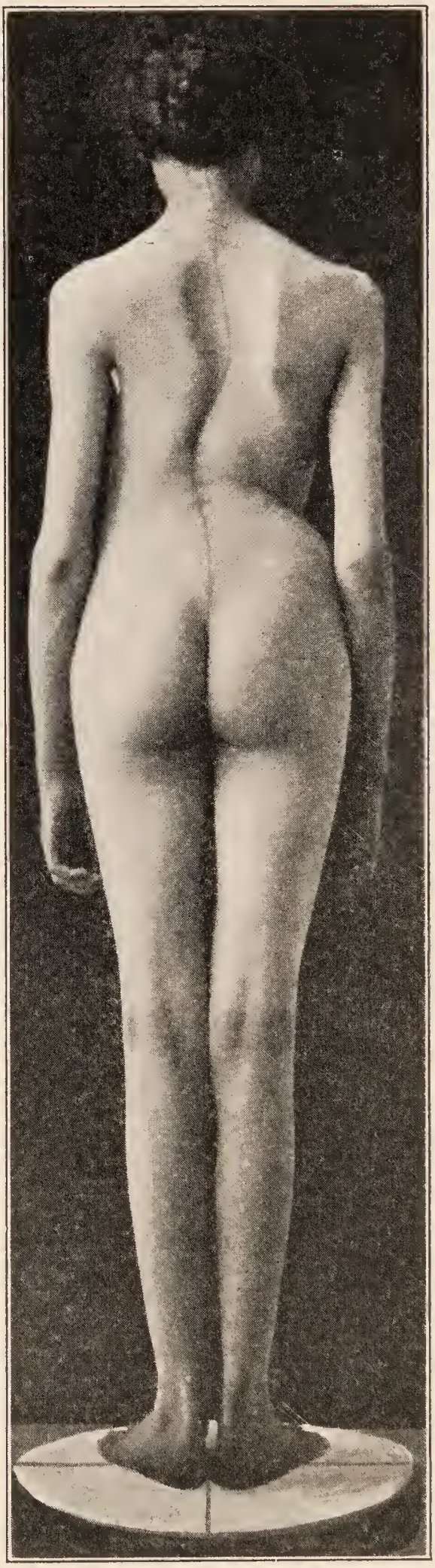


FIG. 233.—Left lumbar scoliosis, showing high hip. (*Spellissy.*)

Böhm suggests that instead of using the term "habitual" lateral curvature, we should speak of these cases as "delayed congenital scoliosis" or "scoliosis congenitalis tarda." His observation is most important and adds one more aetiological factor to our list (Fig. 232).

5. **Age.**—Childhood is the time when, from whatever cause, these osseous changes and rapid growth occur and predisposes to the production of this condition (Fig. 233).

Causes in General.

Causes may be stated as: (1) Predisposing from debility, rickets, defective development, childhood, etc. (2) Exciting which disturb the equilibrium, such as vicious attitudes, paralysis, empyema, etc.

Pathology.

Pathological changes do not result from disease but from pressure and improper functional use of bones that we know will yield. In bad cases all the bones of the trunk may be involved, including the pelvis, primarily or secondarily, but the change is seen most markedly in the bodies, articular and transverse processes of the vertebrae and the ribs. The changes vary according to the amount of the curvature and rotation. Muscles and ligaments are altered only in tonicity and length, for degenerative changes occur only later in the severest cases. The writer found even in supposed normal spines of a large number examined and measured by micrometer for Doctor Bradford at the Warren Museum of the Harvard Medical School, that the two sides of the individual vertebrae were not symmetrical. In scoliosis, after the flexible stage has passed into the fixed stage, this asymmetry becomes greatly exaggerated. In the fixed stage, it is found on the concave side of the curve, that the bodies of the vertebrae are less thick, than on the convex. They, therefore have received the name of the "scoliotic wedges." This change in shape is brought about by physiological processes, as pointed out by Wolff, to meet pathological static demands of pressure, torsion and shearing strain and results not in an atrophy of the concave side, as formerly taught under the Volkmann-Hueter hypothesis, but of a condensation or osterscleroses of the trabeculae to stand increased weight-bearing and a trabecular resorption or osteoporosis on the convex side on which less strain is put (Fig. 234). Wolff has clearly shown that the external contour and internal architecture in bones are mutually dependent on the function demanded.



FIG. 234.—A cross section of a "Scoliotic Wedge," showing osteosclerosis on concave side and osteoporosis on convex.

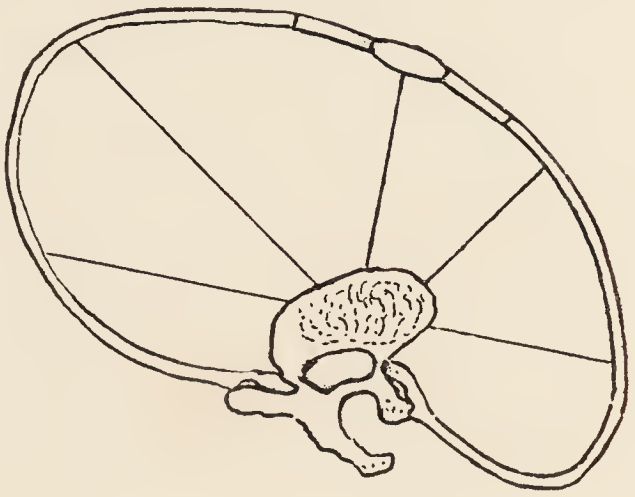


FIG. 235.—Cross section of thorax in region of right dorsal scoliosis. (*Hoffa.*)



FIG. 236.—X-ray of an "*S*" shaped scoliosis. Note the greater separation of ribs on the right, wedge-shaped bodies and intervertebral cartilages; also a wedge-shaped 6th lumbar vertebra.

The inter-vertebral cartilages undergo similar wedge shape changes and one can well understand that any column made up of quadrilaterally shaped bodies

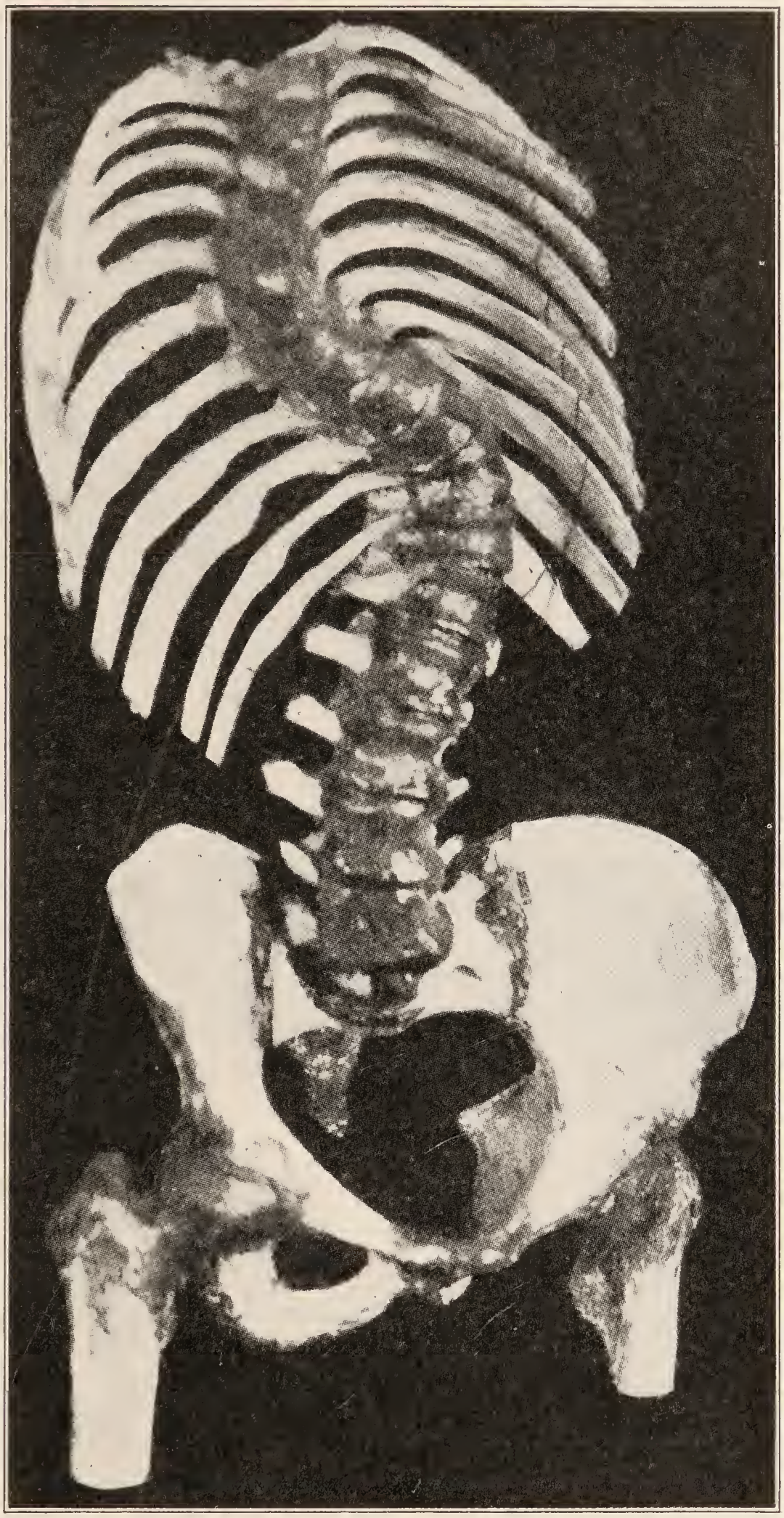


FIG. 237.—Lateral curvature. Bony specimen. (*Philadelphia College of Physicians.*) Note similarity to X-ray (Fig. 236).

(on section), upon being made into an arc, would necessitate the side of each body on the concave side of the curve becoming narrower, more compact, than the side on the convex.

The changes in the shapes of the spinous, articular and transverse processes are explained chiefly by the torsion which invariably takes place in scoliosis. This is brought about by the resistance experienced by bones from ligamentous and muscular attachment, thus if the vertebral body is rotated to the right, the muscular and ligamentous attachments resist a coincident rotation of the spinous process to the left and hence the spinous process gradually yields partially and becomes curved somewhat to the right, so that its tip is no longer directly in an imaginary line drawn from the centre of the posterior edge of the vertebral body, but to the right of it (Fig. 235).

Similarly, in the dorsal region, the ribs being attached by strong liga-

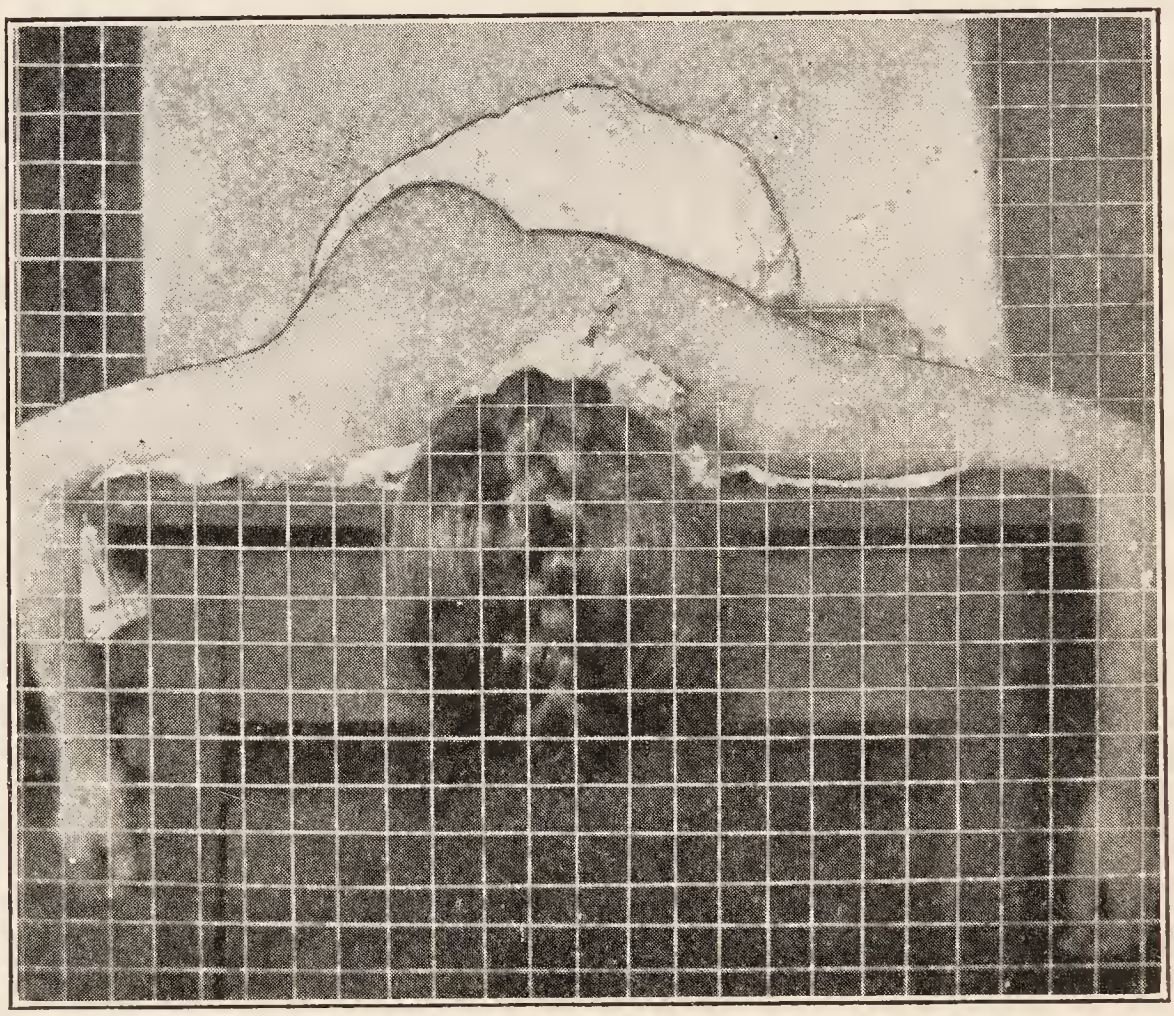


FIG. 238.—Case shown in Fig. 226 sighted down the back, showing marked rotation backward of ribs on the right side. Patient prone on table.

ments to the transverse processes can permit of little movements of the latter in which they do not participate, so that when any rotation backward of a transverse process occurs its rib is carried backward also and the costal angle becomes bent more acutely, while the corresponding rib is carried forward and its angle flattened out or rendered more obtuse. The ribs are not only rotated forward or backward and changed in shape, but they are directed upward or downward, as the case may be, and are further apart on the convex side than on the concave (Fig. 236 and 237).

Pari passu or simultaneously with these changes the tip of the sternum may be deflected toward the side of the dorsal convexity.

Even in severe cases but little change occurs in the clavicles, although the external half of a right clavicle may be more curved than normal in severe right dorsal scoliosis. The scapula on the side of the dorsal convexity is unduly elevated by the backward protruding ribs and removed outward from the median line, while the other scapula having its costal support withdrawn sinks downward

and its inferior angle approaches abnormally near the spinal column; the scapula over the convexity is more concave and that over the concavity is more flattened than normal (Fig. 226).

The thorax is therefore necessarily much distorted over the convex curve in the back where the ribs project or bulge abnormally backward, while on the opposite side, it is flattened or hollowed (Figs. 238). In front the reverse occurs and in larger girls the mamma corresponding with the concave side of the dorsal curve is the more prominent. The umbilicus may be deflected from the median line. When rotation occurs in the lumbar region where no ribs are attached, the deformity is not so marked, but some of the lumbar muscles project on the convex side and are depressed on the other, as has been stated under physical signs. Thus the contour of that region is slightly altered comparatively with the dorsal region and the trouble is evident chiefly in an increased furrow above one hip making it more prominent and the individual seeming "longer waisted" on the side of the dorsal convexity (Fig. 233).

In the severest fixed cases a formative osteitis may ankylose the articular processes of the vertebrae together. The capacity of that side of the thorax into which the convexity projects is lessened as the bodies of the vertebrae encroach more and more upon it and the ribs in front are flattened and their angles decreased behind. On the other hand the diagonal diameter of thorax from the ribs of the convex side forward is greater than normal and that of the other side less (Figs. 235 and 238). In very severe cases, the ribs on the concave side may sink into the pelvis and change the shape of its bone; this is especially true in cases where there is marked inclination of the trunk to the opposite side.

The muscles and ligaments as stated are only found changed in the severest cases; degeneration of the former occurs first on the concave side with adaptive shortening of the ligaments. (Phelps.)

Prominence of the dorsal and lumbar muscles in scoliosis has been mistaken for abscess and incised or explored with an aspirator. Neither compression of the spinal nerves (owing to the large size of the foramina) nor are changes in the spinal cord liable to occur in scoliosis. Berg was unable to detect any reaction of degeneration in the nerves supplying the "extrinsic" spinal muscles, i.e., the superficial group of back muscles.

The thoracic viscera are more often displaced than the abdominal and the capacity of the chest, as was shown above, of one side may be smaller than the other, but no statistics of phthisis exist as a consequence. The liver may be displaced, the spleen compressed and the greater curvature of the stomach may be near or below the umbilicus in the cases of enteroptosis complicating this condition.

Unlike reptiles and fish as types possessing the most marked power of lateral bending of the vertebral column, the human spine, except in infancy, to a still less degree in old age, has but little, without a coincident twisting or rotation owing to the shape of its integral parts. The ligamentous attachments between the parallel transverse and spinous processes also limit lateral bending.

Motions, however, in flexion and extension can be executed with ease normally and in certain regions rotation readily occurs.

At the occipito-atlantoidal articulation we have all three motions, namely, flexion, lateral bending and to a lesser degree rotation.

At the atlanto-axiod articulation we have chiefly rotation.

The remaining cervical vertebrae, on account of the concavo-convex superposition of the bodies, which are longer transversely than antero-posteriorly and the transversely articulating articular processes, permit motions chiefly in flexion and extension and these very conditions together with the horizontal overlapping transverse and spinous processes with their anchoring ligaments and muscles check motions in rotation and lateral bending.

When we examine the dorsal vertebrae we find on the other hand spherical or heart-shaped bodies (with the apex anterior), obliquely articulating articular processes and oblique or vertical overlapping spinous processes so that rotation and lateral oblique bending can more easily take place, and flexion is more limited than elsewhere in the spine.

In the lumbar region the shape and relation of the vertebrae and the mechanical function are quite similar to the lower cervical region, namely, that flexion and extension are more natural than rotation or lateral bending, although the last two are more commonly seen and to a greater degree in the lumbar than the cervical region.

Thus it is easy to understand why the rotation is so much more marked in the dorsal region than in the others.

As in every kyphosis we have a compensatory lordosis, so in a backward rotation in the upper part of the spine to the right, by the law of compensation we must have a backward rotation to the *left* below and vice versa.

Diagnosis.

In slight cases, diagnosis is only made on careful examination. In severe cases it is evident at a glance. To systematically examine a case, the back should be bared by stripping the patient to the trochanters. Mark the tips of the spinous processes, the inferior angles of the scapulae, crests of the ilia and anterior and posterior superior iliac spines with a skin pencil. Attach by means of surgeon's plaster, a plumb line to the seventh cervical vertebra. Then one can measure any deviation, if present, of the spinous processes and any difference in the distance of the two inferior scapular angles from the vertical line and the height one is above the other. Note any projection or difference in contour of the two sides of the thorax and lumbar region as seen from behind. Also any elevation of a shoulder or prominence of a hip or mamma and deviation of xiphoid cartilage or umbilicus from the median line of the body. Then note any asymmetry that exists when the patient is viewed from above, or when stooping over is viewed from below. Examine the amount of flexibility of the spine by holding the pelvis when the patient sits or stands, and then bends laterally as far as possible. Also one may test the flexibility of the lumbar spines by placing as many ½-inch blocks as possible under each foot without flexing the knees, but with both legs straight. This is to be done first on one side then on the other.

The possible rotation flexibility of a spine is to be tested by having patient sit on a revolving stool and turn while the shoulders are fixed. (Bradford and Lovett.) "Fixed" rotation is determined by making the patient lie recumbent or by suspension, when if "flexible" and not "fixed," the asymmetry of the

ribs, etc., and in the contour of the back will disappear. Tests of strength of back, arms, shoulders, sides, etc., can be made by spring balance dynamometers, which with weight and height records can be compared with the tables of the average for that age. (Bowditch's.) The length of the legs should be measured not only from the anterior superior spines of the ilia to the internal malleoli, but from the major trochanters to the external malleoli and also from the highest point of the crest of the ilia to the external malleoli. Flat foot on either side is also to be noted and taken into consideration. The inclination of the pelvis on each side should also be determined by a suitable balance or level between the anterior and posterior iliac spines, such as the leveling trapezium of Schulthess.

Records of Cases.

Records can be kept by measuring the distance of the tips of the spinous processes, inferior scapular angles and points of greatest prominence from the plumb line (vide supra) and plotting on plotting paper or by the method described under Surgical Mensuration.

The most convenient method is perhaps by means of photographs taken through a frame upon which, at vertical and horizontal intervals of an inch, cord or wire is stretched and the measurements can then be seen at once on the photographs in inches and any change would be apparent in the next photograph, if improvement or the reverse had resulted from treatment (Fig. 226). The same light and shadows are to be used in subsequent photographs to avoid error and the position is to be the same especially with regard to the frame. Thus an exact record of each case can be kept from time to time. In the absence of photographs outline sketches made at stated intervals are of some value and the tracing apparatus of Schulthess[1] is accurate.

The author would also suggest the following method to determine the angle of rotation in scoliosis; the patient is made to lie prone on the examining table, the face turned to the left in right dorsal scoliosis and to the right in left dorsal curvature, with the arms at the side, palms of the hands down and the elbows as close to the body as possible.

A yard stick is placed across the spine at the point of greatest rotation with its centre at the spinous process of that region, the vertical distance from the two extremities of this stick to the examining table or floor is then measured by a graduated rectangular triangle, such as one may obtain at a store where drawing instruments are sold.

Now in a symmetrical back these two extremities would be equidistant from the table or floor. The difference between the two, in distance from the table, in a rotated spine, would give the side of a rectangular triangle opposite the angle to be determined, if we imagine a plane parallel to the normal back plane or to the table as one side of the triangle.

The normal plane of the back may be easily determined in a rotated spine as it is the same distance below the upper extremity of the yard stick that it is above the lower extremity of it. Suppose a beam to be perfectly balanced at its centre, each end would be equidistant from the ground; this we may call the

[1]Joachimsthal's Handb. d. orth. Chir., Bd. iii, iv, v, page 35.

the normal plane of the back. Now suppose this beam is rocked on its central point of balance, which occurs in a rotated spine, one will be as much above the normal plane as the other is below it, and the diagonal angles opposite made by the intersection of the rocked beam with the normal plane will be equal. As the normal plane is parallel with the ground, any angle formed with it, or any parallel plane, will be the same as that formed with the ground. Now this can readily be applied to the rotated scoliotic spine in a prone position, for when any angle is made by the rotated spine with the normal spinal plane the same angle is made with the examining table or any plane parallel to it, as is well known from geometry ("alternate interior angles are equal").

Now to apply the yard stick method to the rotated spine:

In Figs. 239 and 240 *CD* represents the yard stick or plane of the rotated spine with its centre at *B* the spinous process and *ET* the examining table or floor. Suppose *CE* is a longer vertical distance than *DT* (as determined by the graduated rectangle triangle).

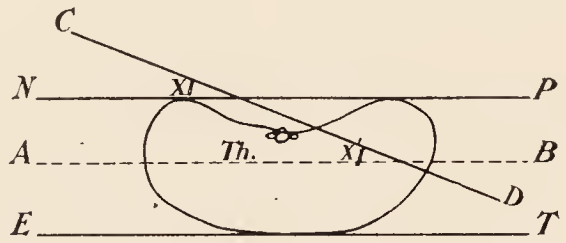


FIG. 239.—Normal plane of the back.

Th., Normal thorax; *NP*, normal plane of the back; *ET*, examining table or ground; *AB*, any plane parallel to *NP* and *ET*.

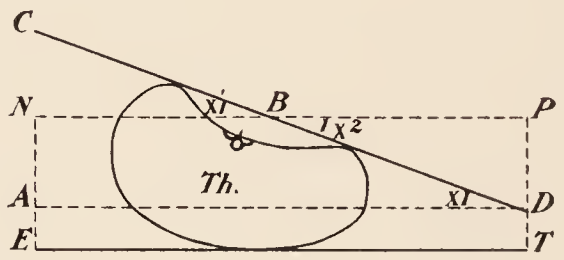


FIG. 240.—Angle of rotation in scoliosis.

Vertical distance $CN = PD$, and $CB = BD$; $CE - DT = CA$, one side of a rectangular triangle; now CA is the side opposite the angle (X) of rotation sought $X = X^1 = X^2 = X^3$.

Now by subtracting *DT* from *CE* leaving *CA* and projecting an imaginary plane from *A* to *B* the line *AB* is parallel to *ET* naturally, as it has been drawn through two points equidistant from *ET*; further, *CAD* is a right angle, as *CET* was and the distance *CA* is the side of a right angled triangle opposite the angle of rotation to be determined, or the identical angle the plane of the rotated spine would make with the examining table or a prolongation of its surface or with the plane of a normal spine (Fig. 240).

Now if *CE* should equal *DT*, *CD* would be parallel to the examing table, coincide with *NP* and no angle would be made naturally and *CB* here would equal the normal plane of the normal back.

If on the other hand *CE* should be 36 inches longer than *DT*, we would have the yard stick vertical to the examining table and the angle of rotation of the spine would be 90°. From these two extremes it is easy to construct a working table.

If the distance in inches between *CE* and *DT* is...	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
The angle in degrees is.....	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90

Now in order to facilitate the working of this method, the author has graduated the sides of the rectangular triangle in inches and had the above table put upon its hypothenuse.

Of course, we all bear in mind the great difficulty of obtaining exact records of the rotation in scoliosis from the natural tendency for the body to assume dissimilar postures on different occasions when records are desired, but whether we use the ancient lead tape for tracings, or the weight bar and plumb of Bradford; or complicated machines such as that of Demeny or Schulthess, we will encounter this same source of error. The above method is not claimed as a perfect one and free of error, but its simplicity of application and the cheapness of the necessary instruments required as does the method suggested under Surgical Mensuration, commend it. Further, from the fact that the patient is to be prone, with the face always turned to one definite side, the palms of the hands down in contact with the examining table the elbows as close to the sides as possible and the lightness of the yard stick, the element of error at the varying periods of examination is minimized.

Differential Diagnosis.

From Pott's Disease, Lateral Curvature is distinguished by the absence, as a rule, of any acute antero-posterior angle, muscular spasm, pain, fixation of the spine (in early cases) and by the presence of rotation. When there is lateral deviation in Pott's Disease there is little rotation as a rule and a diagnosis of Pott's Disease has usually been made previously from the night-cries, attitude, pain, etc., even if a "knuckle" is not present. One practically never sees true scoliosis without rotation.

Prognosis.

I. The prognosis without treatment, as to self-limitation or increase of the deformity, depends on:

1. The general health of the patient.
2. The severity and fixedness of the curve and the amount of rotation.
3. Rapidity of growth and an hereditary tendency to height are unfavorable.
4. The time of second dentition is especially unfavorable for the arrest of this condition. (A child grows more from the middle of July to the middle of November than at any other time of the year.)
5. Rickets and phthisis are unfavorable.

Spontaneous disappearance of the deformity in a growing child is most rare. Predictions of the rapidity of the increase of a deformity or the permanency of the arrest of the distortion should be most guarded. It is more common to see an increase in the growing years but it is also seen occasionally in slowly developing adults.

II. Prognosis with efficient treatment.

1. If the general health is good and even if the curve is very marked, but flexible, it may become corrected.
2. The more rotation, of course, the more difficult the cure or marked improvement.
3. The position of the curve influences the efficiency of treatment. Dorsal curvature is the most difficult to treat. Lateral curvature in Pott's Disease in the earlier stages is easily corrected by suitable treatment of the primary disease (vide supra). In late Pott's Disease, where ossific changes and ankylosis have

occurred, no treatment is available, of course. In general it may be stated that with efficient treatment the increase in the fixed curvature may be checked and in the majority of cases there is marked improvement. In the severest types and neglected cases the great aim should be to keep them from getting worse and hold the deformity, at least.

Treatment.

Under the treatment of scoliosis, preventive measures will be considered first, and then the treatment of developed cases.



FIG. 241.—Common faulty attitude in children, which produces right dorsal and left lumbar curvature in sitting.

Preventive Measures.

As faulty attitude plays such an important part in the development of scoliosis by destroying the equilibrium of the body and throwing a constant strain and stretch on one set of muscles thereby weakening it, while its fellow on the opposite side of the body is unduly relaxed, thereby undergoing adaptive shortening, attention to positions, habits of attitude and the like in growing children seems of the first importance, more especially where they are delicate or rapidly developing. These points may be noticed in the following ways:

1. **In Standing.**—Habitual attitudes of throwing all the weight on one leg and not assuming the "attitude of rest" when the two legs are fully extended and bear the weight of the body equally, may be considered faulty and to be avoided. Proper balancing of the body should be taught, with head erect, chin in, shoulders back, chest thrown forward, hips back, feet adducted and legs sufficiently separated to afford an easy, comfortable equilibrium. This is the "attitude of rest" (Figs. 191 and 210). Weak children can be much helped in attaining this, by out-of-door exercises, gymnastics or Swedish movements, or home exercises under skilled supervision. Military schools will help in the case of boys. The keynote to all the exercises, however, should be to keep a correct balance, approaching the attitude of rest as nearly as possible, from which all standing exercises should be taken. In cases that stand with the weight thrown on one side from short leg, muscular weakness, a bad knee or ankle or flat foot suitable measures should be taken to correct these troubles by having the shoe sole thickened the desired amount (Fig. 249). When prolonged standing is necessary, as in church, school, etc., a weak child will find relief in advancing one foot *forward* or *backward* and still keep the spine erect. It is the placing of one foot *far to one side* and resting the weight entirely and habitually on the other leg that destroys the equilibrium. Cases have also come under the author's care with very severe right dorsal scoliosis from prolonged practicing on the violin, in those who had a predisposition to spinal weakness. The violin masters require these pupils to be able to see their left elbows under the body of the violin, thus throwing the dorsal and lumbar spine to the right of the median line. Folding the arms over the chest contracts it and is a bad habit as is, in boys, the habit of thrusting the hands into the trousers pockets (Figs. 202, 204, 208, 241 and 242).

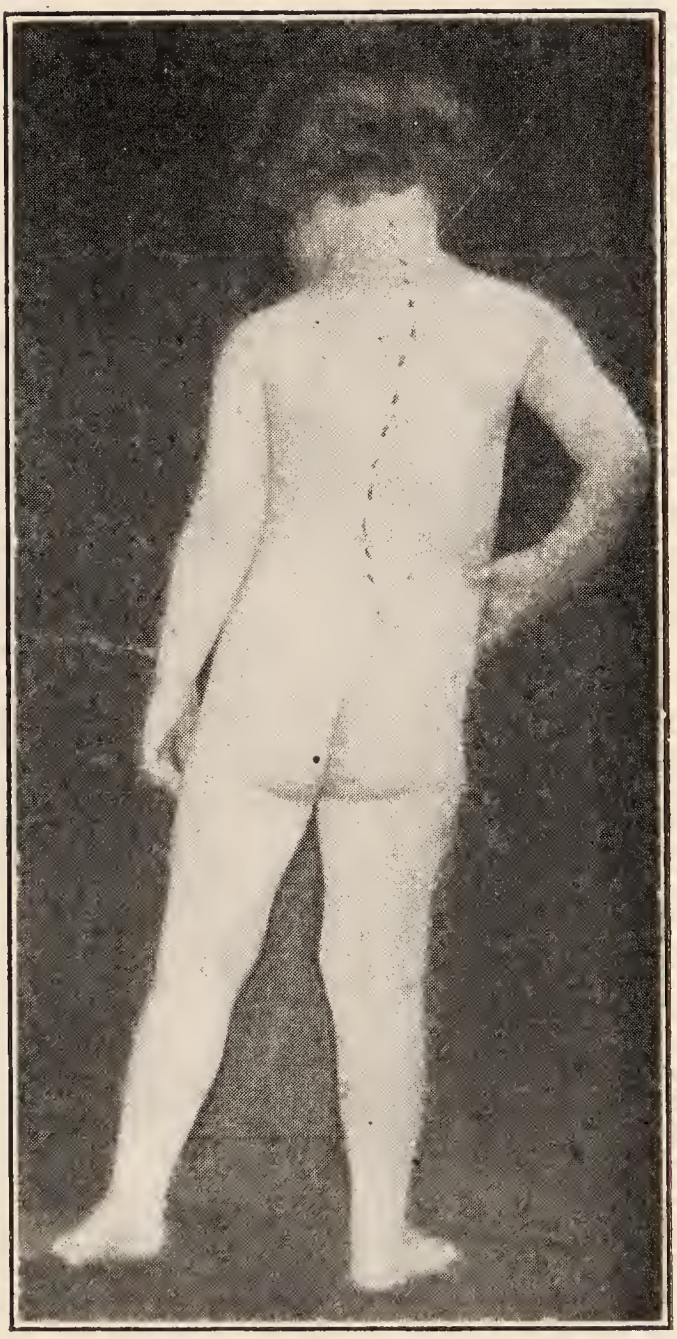


FIG. 242.—The same faulty attitude in standing.

2. **In Walking.**—The carriage should be symmetrical on the two sides and the head and trunk held as in standing, save the body may be flexed forward at the hips. The hands should not be carried in the pockets nor should one hand be used for carrying weights more than the other. Children come under observation who develop the habit of carrying one shoulder higher than the other from taking under one arm a large pile of school-books or bundles.

3. **Sitting.**—Many faulty attitudes assumed by school children and children at home as well, may be considered as the cause of some of the cases of lateral

curvature. These attitudes are more often than not the result of improper chairs and seats, or in other words, those that *do not fit and support the child*. A chair or school desk-seat should have a back with an inclination backward of 100 to 110° with the seat. The seat proper should be as wide, generally speaking, as the child's thighs, including the buttocks, are long, from the flexed knee. There should be an inclined foot support for the fully extended legs either on the floor or attached to the chair. But perhaps most important of all every chair should have on the back as part of it, or attachable, a pad that fits exactly and supports well the lumbar region.[1] Piano and desk-stools should have backs that fit well into the lower dorsal and lumbar regions. A reclining chair should fit into the physiological curves of the spine and have a forward convexity under the occiput to fit into the cervical region as well as at the lumbar concavity. Reading and writing naturally come under this heading, and the position of the table or desk is important and its height should be proportioned to the person sitting. The distance from the top of the seat to the top of the table should be $\frac{1}{8}$ the height of a girl and $\frac{1}{7}$ that of a boy or two inches plus the distance from the olecranon of the semiflexed forearm to the seat. The edge of the desk should be just over the edge of the seat. The inclination of the top of the desk should be a slope of two inches in a breadth of twelve.[2] Many different and faulty attitudes and twistings of the body are assumed in writing. Bradford and Lovett say: "The proper attitude during writing is with the transverse axis of the trunk parallel with the edge of the writing table. The forearms should rest for at least $\frac{2}{3}$ of their length upon the table. The trunk should be held erect, the legs should be straight before the trunk and the feet should rest upon a sloping cricket, to support and steady the legs" (Figs. 202 to 206).

4. **In Sleeping.**—Statistics go to show that the most common attitude in sleep is faulty, i.e., on one or the other side, although the dorsal decubitus is more common than upon either single side. A child should not be allowed to assume a twisted or contracted position and should be taught perferably to sleep on its back, as freer chest expansion is thereby obtained from the dorsal attachment of the ribs to the spine. In threatening cases, Bradford bed frames may be used to ensure a proper position. In a developed case, the patient should sleep on the side of the greatest concavity or the back. A firm bed and no pillow should be the rule (Figs. 207, 208 and 209).

5. **Corsets.**—Hutchinson[3] has shown that corsets weaken the muscles of the trunk and are to be avoided in developing girls. The injury from corsets may be made less by having elastic lacings and the waist without steels or supported by light bones only. Corsets are never the shape of the human thorax and the prevailing mode of bloused waists render their use entirely superfluous in the majority of cases. The less tone a girl has, the more relaxed and flabby she is, the more reason there should be for her not wearing corsets and taking exercises to improve her condition. Ferris waists, the equipoise waists or ribbon corsets offer the best substitutes for corsets.

[1] Staffel, Centralblatt f. orthop. Chir., May 1, 1885.
[2] Staffel, Ibid.
[3] Med. Record, 1889, vol. i, page 464.

Treatment of Developed Lateral Curvature.

Lateral curvature, being a condition usually that manifests itself and is most active during the growing years of life, requires long and careful watching, which necessarily becomes trying to the parent and monotonous to the patient and surgeon, therefore treatment is difficult to enforce and results must necessarily vary with the degree of accord that exists between the patient and the surgeon. As a consequence of this, no definite promises can be made as to the outcome of treatment, especially in bad cases and as it does not imperil life when untreated, as is the case in Pott's Disease, the patient has to go into it very earnestly, seriously, and persistently to hope for a good result and confidence in and obedience to the detailed treatment is essential. As a consequence of the tediousness and uncertainty of results, many physicians turn their cases over to Swedes or gymnasium instructors unskilled in "corrective work," without routine direction of the treatment and then to a large extent their responsibility ceases. The treatment, however, by these means may yield in mild cases good results, but are attained as a rule unscientifically, as the treatment is directed against the prominent shoulder, hips, or ribs and the primary causative condition, i.e., the deviated spine, is lost sight of. The treatment by orthopaedic surgeons varies of course with the activity of the disease and its extent. It has three chief aims.

1. The removal of the superimposed weight resting on an habitual lateral deviation of the spine.

2. Strengthening and restoring the equilibrium in the osseous, ligamentous and muscular elements in the trunk.

3. To reduce or remove the deformity.

I. To remove the superimposed weight, two means are adopted, (*a*) recumbency and (*b*) suspension.

(*a*) Recumbency is one of the oldest forms of treatment and is most helpful in all cases and especially those in which the deformity is rapidly developing and where there is general weakness and slight endurance. The great objection, however, to it when prolonged is that when persisted in for months as an indoor treatment, the general health suffers and the conditions which promote the formation of solid bone and firm strong muscles are interfered with. Where there are neurasthenic pains, however, recumbency carried to the extent of several hours a day will be found most useful if supplemented with massage. As a rule in all cases where there is a tendency to be easily fatigued or a condition of lowered vitality from too rapid growth, etc., recumbency should be advised in the form of early retiring, late rising and a period of afternoon recumbency more or less prolonged, depending on the severity of the case.

(*b*) Suspension as a rule means by the head and hands equally without muscular effort. To hang by the head only has seemed severe and perhaps dangerous to the writer, but in McKenzie's cases has proved efficient.[1] The best means for attaining suspension are by the ordinary head-sling attached to a rope passing over a pulley, the other end of which has a cross bar of wood or knobs for the hands whereby an equal distribution of weight can be maintained.

[1] Trans., Amer. Ortho. Assoc., vol. vii. Galloway, Annual Jour. Winnipeg Med. Chir. Soc , 1905–1906.

It goes without saying that actual suspension for a prolonged period is out of the question, but as a daily exercise either vertically or on an inclined plane, it does good in removing superincumbent weight and in lengthening muscles and ligaments that have undergone adaptive shortening. It may also relieve the discomfort which is caused by the unequal distribution of the weight of the trunk on a weakened spine with muscular contractions. Exercises in swinging on the trapeze may also do good in the same way. By means of a head support or "jury mast" partial suspension is obtainable and is most beneficial in mild cervical and upper dorsal cases and essential in some severe cases (Fig. 155). However, it is to be remembered, except in mild cases (and the same holds in recumbency), that distraction by a direct pull is no more efficient in obliterating a bad curve in true scoliosis than in spondylitis, but simply removes the physiological curves, i.e., straightens them out.

II. The strengthening and restoration of the equilibrium in the trunk may be divided into its constituents for convenience, as (*a*) bone, (*b*) ligaments, (*c*) muscles.

(*a*) Bone development and strength must be gained by observing the laws of general hygiene by stimulating cold baths, exercises and fresh air and such diet and tonics as promote digestion, assimilation, etc.

Trabecular balance or equalization of strain on the two sides of the vertebrae must be gained according to Wolff's law by *over-correction* of the deformity in flexibles cases, as far as possible (vide infra).

(*b*) The ligaments are helped by such means as reestablish the equilibrium, take the strain off one side and make the relaxed side bear its portion of the burden. These means are promoted by recumbency and suspension, by a drill in the proper attitude or by supports which hold the trunk erect or tend to over-correct the deformity (vide infra).

(*c*) *Muscles.*—Under muscular improvement comes that most important subject of Gymnastics, which should be employed in all cases of lateral curvature. Various authorities differ in the choice of exercises for the treatment of lateral curvature as one exercise in one man's hands may prove most efficient in a certain class of cases, while to another it may be of no value, as so much depends upon the way it is executed. All seem to concur in choosing exercises for increasing the flexibility and strength of the spinal column and muscular development of the shoulders and hips. As each exercise which has proven efficient in a similar case may not be useful in the one before him, therefore the patient with back bared to the trochanters should be made to go through the various prescribed exercises in the surgeon's presence to determine their efficiency in each individual case. Thus the surgeon can write a prescription of exercises suited to the peculiar and particular requirements of the case. It is important also not to fatigue the patient by prolonged exercises and the movements at first should err on the side of being too short rather than the reverse, especially in those cases of lowered vitality and general debility. Thus will be apparent the unwisdom of class drills or exercises and the importance of treating the individual. Executing each motion from three to five times at the beginning will be found ample. Of great importance is the way in which a movement is executed, whether done *with a vim* or listlessly, or in a faulty attitude, or with

the knees or elbows bent when the reverse is essential, whether the correction aimed at is accomplished, etc. As a rule in mild cases a few exercises carefully executed twice daily will be found all that is necessary. In giving a list to a patient the exercises may be prescribed from a previously made lot of exercises which are adapted to cases in the different regions, but only after trial.

Swedish Gymnastics.

Gymnastic exercises in general are utilized for general muscular development but in lateral curvature, it is very essential to prescribe certain definite exercises to accomplish certain definite aims and each exercise should be done before the surgeon or his skilled gymnast to see that the scoliosis is helped thereby and in the case of a double curvature that one curve was not helped at the expense of the other. Therefore it is most unwise, or at least a question of doubtful benefit, to send a scoliotic patient to a general gymnasium or to a gymnast unskilled in corrective work.

Hanging rings and pulley weights also are bad as allowing the hands to come close together and thus promote chest contraction.

However, as many scoliotics are deficient in general muscular development, have insufficient or sluggish circulations and poor lung expansions, general gymnastic exercises carefully chosen must be prescribed to overcome these atonic conditions, as well as the special exercises to correct or lessen the curvatures.

Further, just as it is found in Pott's Disease that the more exaggerated the compensatory physiological curves became, the greater apparently is the deformity, so in scoliosis, we will find the greater the lumbar lordosis, the worse the scoliotic curves become. The converse of this is easily demonstrated by requesting a patient to hold the head up, chin in, chest out and abdomen back and at the same time overcome the lordosis by flexing the thighs on the body as in sitting or hanging in the "hook position" or in "hook lying" and then noting that the curvature is lessened somewhat (Figs. 217 and 248).

In order to carry out special or general Swedish movements for an individual case of scoliosis, but little apparatus is needed, viz. an inclined bar in a doorway, which can be made of a broomstick; a square stool of sufficient height to allow the patient's feet to rest squarely on the floor; a box of sufficient size to allow the patient to sit on it and gymnast to stand on it at the same time; a strip of wood with straps for the feet fastened obliquely against the chair-board and an oblong stool on a board sufficiently high for the patient to ride sitting astride thereon and have the feet fastened by straps to a board on the floor. For the specialist a regular Swedish boom, stall-bars, plinth, etc., will be most useful and one should refer to such special works as Anders Wide's Hand Book of Medical and Orthopaedic Gymnastics[1] to get a thorough insight into this subject.

Swedish movements may be divided into active, passive and resisted movements: an active movement is one which the patient executes voluntarily by his or her own power; a passive movement is executed by the gymnast on some part of the patient's body and a movement with resistance may be either executed

[1] Funk and Wagnalls Company, New York.

by the patient and resisted by the gymnast or executed by the gymnast and resisted by the patient, depending on the effect desired.

All Swedish movements are taken from what are termed fundamental positions, namely, in (1) standing, (2) sitting, (3) lying or (4) hanging.

1. The standing fundamental position is with the head erect, chin in, chest out, abdomen in and hips drawn well back. The majority of Swedish books and gymnastic teachers require the patient to stand with the heels together and the long axes of the feet at 90° with each other. This is a weak position and detrimental to the arch of the foot, so that it is better to stand in what the Swedes call "close standing" with feet touching each other all along their inner

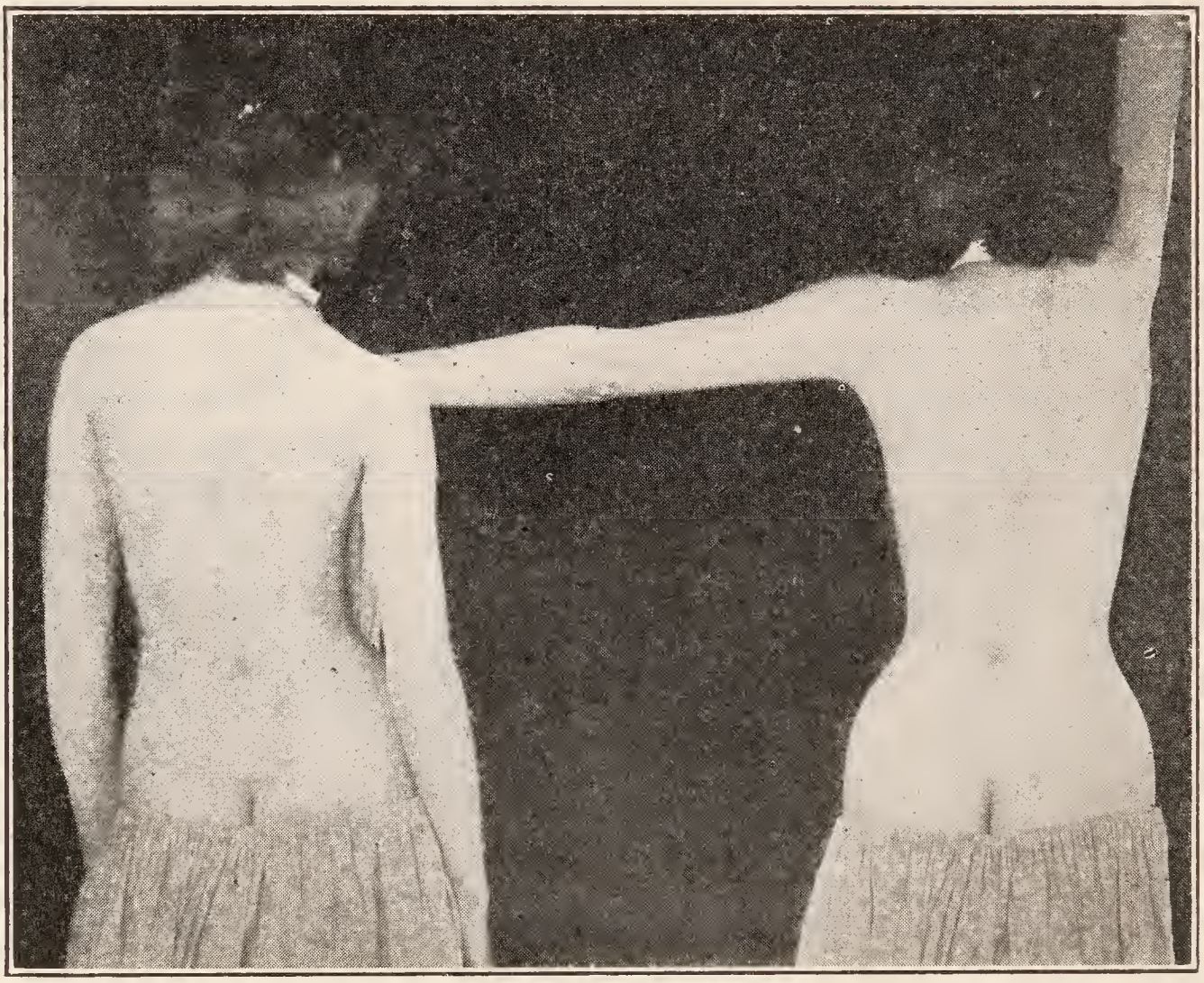


FIG. 243.—Double photographic exposure, showing deformity and self-correction in a total left dorso-lumbar scoliosis by the "Keynote" position in the same girl.

sides or with their axes parallel at least. The arms hang freely at the sides with palms of hands against thighs and fingers close together.

2. In the sitting fundamental position the thighs are at a right angle to the trunk, the legs at 90° to thighs, the feet are firmly together on the floor and the knees together and the arms hang at the sides.

3. In lying the patient lies on the back, the arms are at the side, palms down and the legs are together, toes up.

4. In hanging the hands are *at least* as far apart as the width of the shoulders and the bar or trapeze is sufficiently high to prevent the toes from touching the ground. The arms are fully extended and the patient hangs passively.

From these fundamental positions innumerable movements or positions may be taken by combinations of definite arm, leg, or trunk attitudes.

Arm Movements.

(*a*) In "wing" position, the hands are placed on the hips, fingers forward, thumbs back.

(*b*) In "bend," the elbows are at the sides and finger tips touch the shoulders.

(*c*) In "swim," the elbows are on a level with the shoulders and radial side of hands toward shoulders.

(*d*) In "yard" or "cross," the arms are fully extended laterally on a level with the shoulders.

(*e*) In "heave" or "cross *e*," arm rotation, the arms are on a level with the shoulders and the forearms at right angles with the arms, either forward or upward.

(*f*) In "reach," the entire arms are carried forward parallel to each other

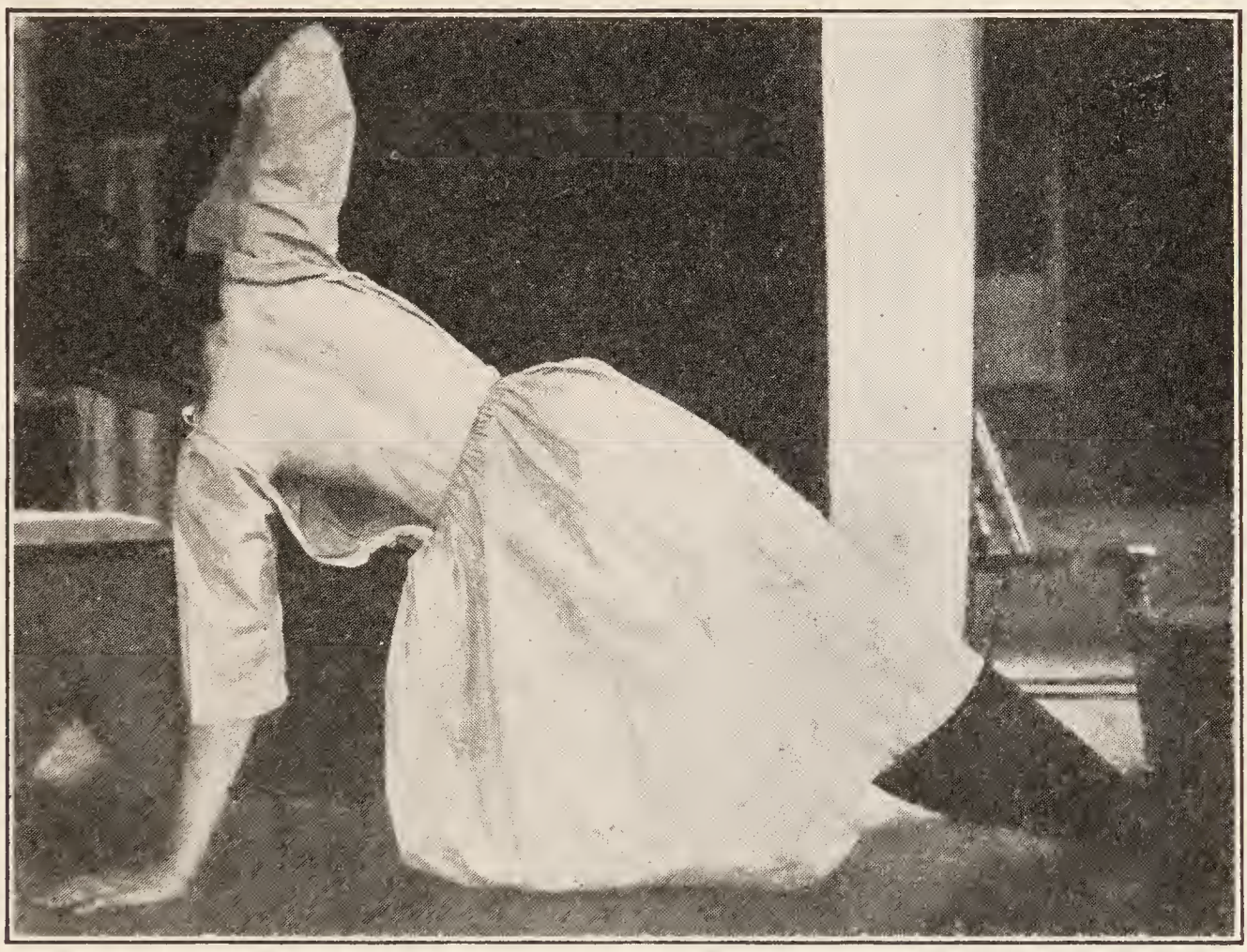


FIG. 244.—Sideways falling to the left for left dorso-lumbar scoliosis. Same case as seen in Fig. 243.

on a level with the shoulders; this is called "grasp" when the hands touch or rest on the wall or any apparatus. If the hands grasp anything this word is added for example, "reach-grasp-standing."

(*g*) "Rest" signifies that the palms of the hands rest on the back of the neck or head, so that the finger tips touch and the elbows are held well backward.

(*h*) "Stretch" means that the arms are fully extended upward.

(*i*) "Half" signifies only one side is to execute a movement, but either "right" or "left" is more commonly used.

Leg Movements.

(*a*) "Toe-standing" is where the patient stands on tip-toe.

(*b*) "Knee-bending," is where the knees are flexed.

(*c*) "Fall-out-standing" is where one foot is advanced forward about a yard, the knee is bent, so that it comes just over the toe-tips, the arm of that side is in the stretch position and with the body and the other fully extended leg, make one plane; the other arm is carried downward and backward parallel to the upstretched arm (compare "spring-sitting," Fig. 214).

(*d*) "High-stepping" consists in tip-toeing, flexing the knees very high, walking forward, toes in or "marking time on the spot."



FIG. 245.—"Sitting, right, reach grasp dumb-bell, left, press over ribs." ("*Hoffa exercise.*")

(*e*) "Prone-standing" means flexing the body forward at the hip joints and not at the waist.

(*f*) "Side bending" and "back bending" need no explanation.

(*g*) "Leg-support-standing" means that the legs lean against or are supported by something.

(*h*) "Forward" and "lateral-falling" mean positions in which the body is supported on the floor by the hands and feet, or one hand and one foot, respectively, with trunk and legs straight (Fig. 244).

Sitting Positions.

The sitting positions, which have definite names as distinguished from the fundamental are:

(*a*) "Long-sitting," where the legs are fully supported (Fig. 216).

(*b*) "Half-sitting" is where one thigh with knee flexed alone supports the weight of the body, the other leg being extended backward (Fig. 246). Also called "spring-sitting."

(*c*) "Stride-sitting" is where the knees and feet are separated some little distance (Fig. 214).

(*d*) "Ride-sitting" is where the patient straddles or sits astride of some apparatus.

(*e*) "Spring-sitting" is practically the same thing as "fall-out-standing," with the flexed thigh supported on a stool, as a "half-sitting" attitude modified (Fig. 246).

Lying Positions.

(*a*) "Stride-lying" means the legs are separated.

(*b*) "Hook-lying" signifies the thighs are flexed on the body and the legs on the thighs (Fig. 217).

(*c*) "Sit-lying" means that the body and thighs are supported, but the legs depend as in sitting.



FIG. 246.—"Spring sitting."



FIG. 247.—Hanging, correction by gymnast of left dorso-lumbar scoliosis.

(*d*) "Half-lying" means the body lies at an angle of 45° on some supporting structure.

(*e*) "Hook-half-lying" combines (*b*) and (*d*).

(*f*) In "prone-lying" the patient lies on the face (Figs. 211 and 212).

(*g*) "Leg-prone-lying" means the legs rest on their anterior surface on some support (Fig. 212).

(*h*) "Side-lying" and "side-leg-lying" need no explanation.

With these simple terms at our disposal, or combinations of them, covering

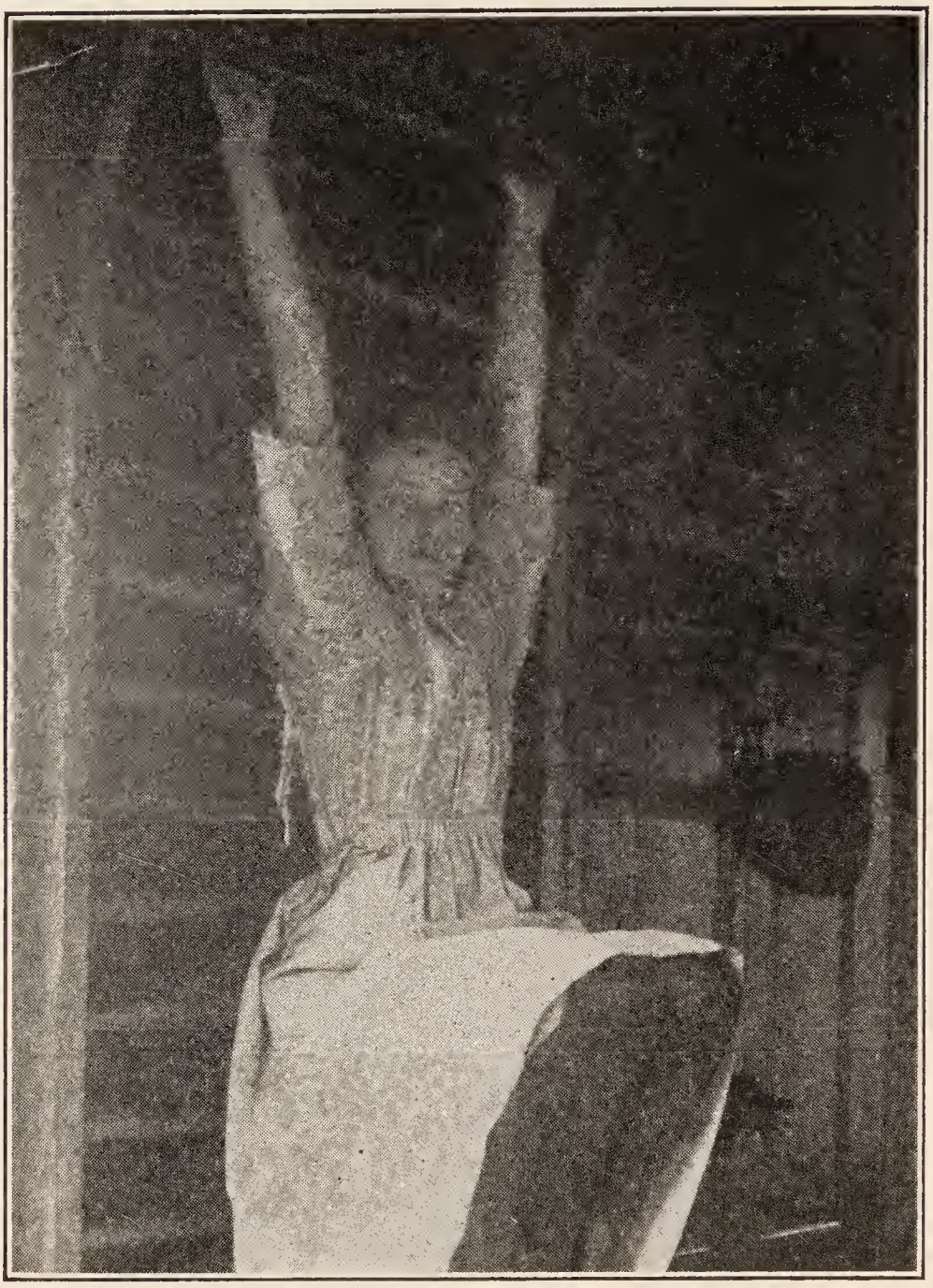


FIG. 248.—Hook hanging.

exercises for the arms, legs and trunk, it is an easy matter to make out a programme for a case in brief language, for example, for general development, we might use.

1. Stretch-standing (15 times), from arms "bend."
2. Yard-standing (15 times), from arms "rest."
3. Heave-standing-arm rotation (15 times).
4. Rest, leg-prone-lying, holding (5 times).
5. Heave-hook-hanging.
6. Stretch, hook-half-lying, arm flexion and extension with resistance.
7. Toe-standing, knee-bending (25 times), etc.

For Cervical Scoliosis.

1. Half yard-grasp-standing, head side-flexion resisted toward the convexity.

2. Prone-lying, head bending backward resisted.

3. Lying, shoulder support, head twisting resisted (for rotation), etc.

For "C" Shaped Right Dorsal Scoliosis.[1]

1. Left arm rest, right arm wing, ride-sitting, right side flexion.

2. Left spring-sitting.

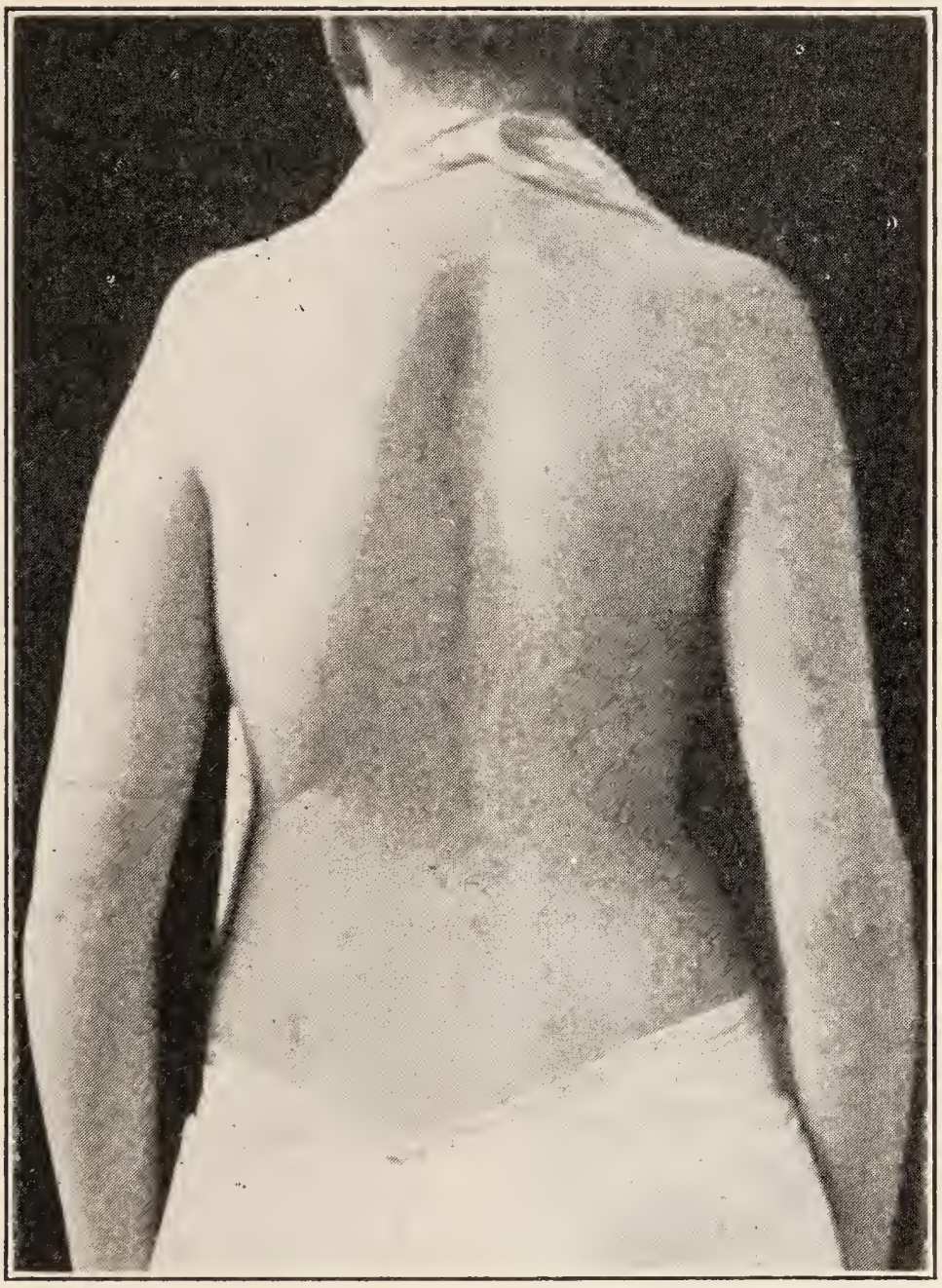


FIG. 249.—Static left dorso-lumbar scoliosis from short left leg due to coxalgia, to be corrected by elevated shoe.

3. Spinal-raising, which is a stretching position of the trunk from wing position.

4. Hanging, inclined boom (left side high) (Fig. 247).

5. Left arm-stretch, right yard, toe standing, knee bending. (Left arm-stretch and right yard in right dorsal scoliosis is known as the "keynote" position or best position the patient can assume for straightening the curve.) (Fig. 243.)

6. Rest, prone-leg-lying, right side-bending, holding.

[1] In the illustrations it is to be noted the exercises are being given for *left* dorso-lumbar scoliosis. For the right curvature the exercises would be just reversed.

7. Left arm rest, right arm yard, side falling (Fig. 244).

8. Hook-hanging (Fig. 248).

9. Lying left leg raising (slowly) or prone-lying right leg extending slowly, resisted.

10. Hanging, fall out, left trunk twisting, etc.

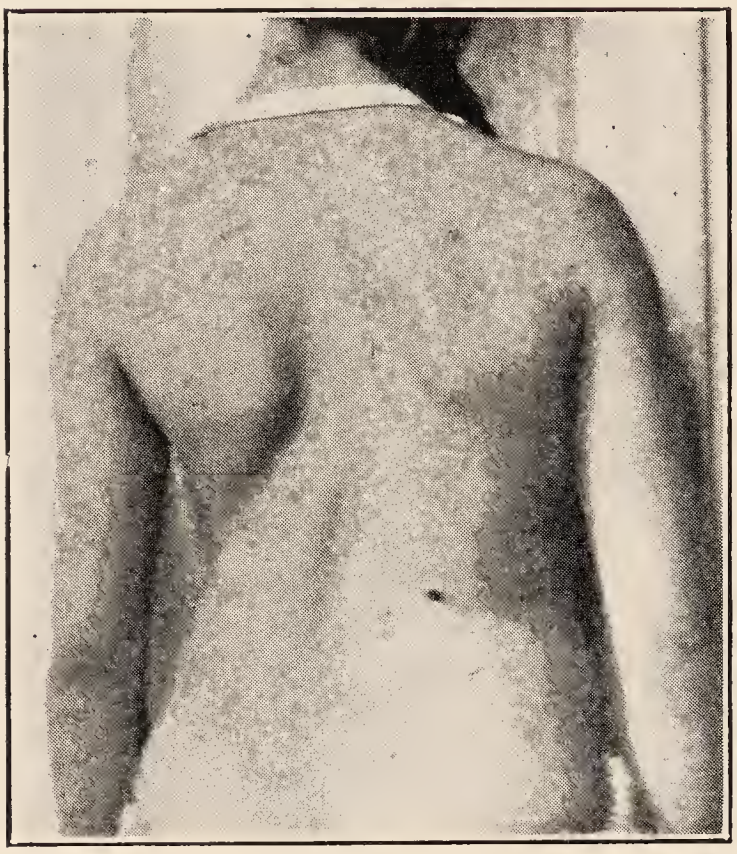


FIG. 250.—Patient before application of author's webbing and adhesive correction brace for flexible cases.

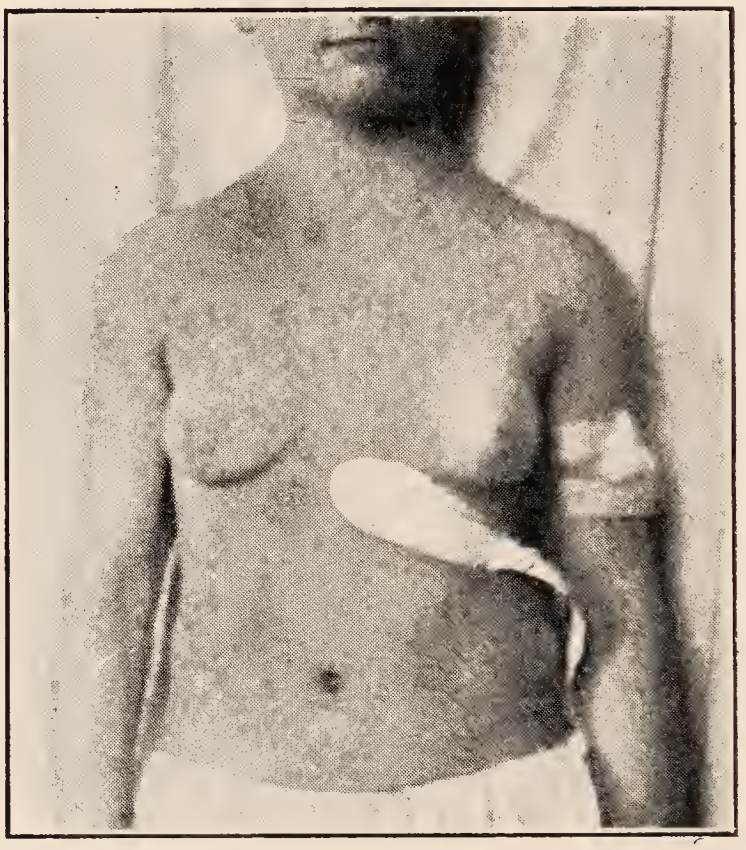


FIG. 251.—Front adhesive and webbing applied.

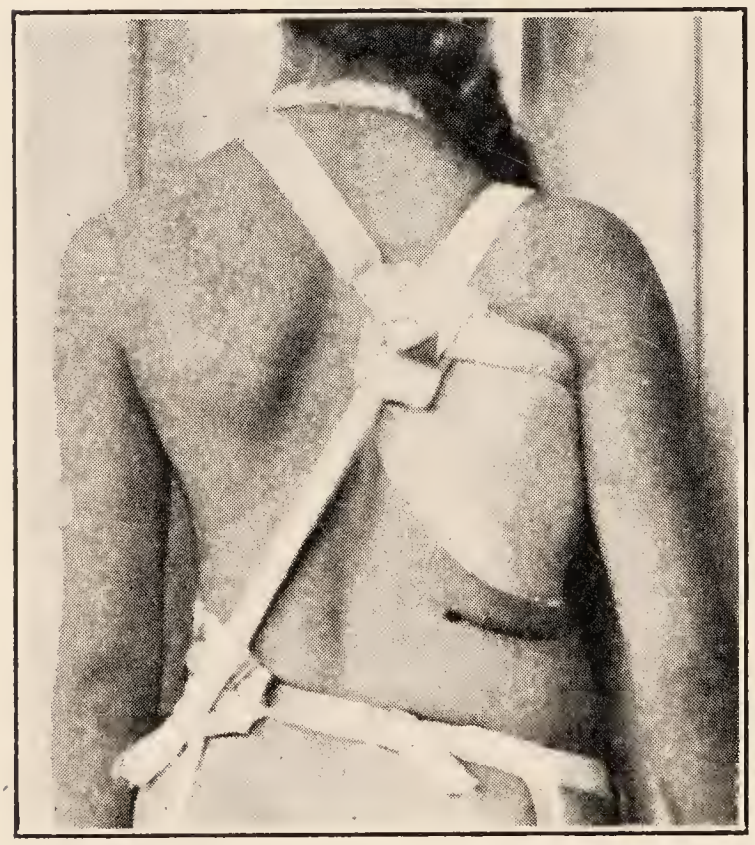


FIG. 252.—Author's webbing correcting brace, back view showing large adhesive over right ribs.



FIG. 253.—Author's webbing correcting brace, front view (page 255).

For lumbar scoliosis (left).

1. Standing right leg adduction or left hip lifting.
2. "Keynote" left side bending.

3. Prone-lying, double-leg carrying to left.
4. Hanging double-leg carrying to left.
5. Left side-falling, right arm rest, left arm grasp, stall-bars, etc.

Stall-bar or rib-stool as it is sometimes called, is a kind of ladder fastened against the wall.

For "S" formed scoliosis the exercises are to be so combined and adapted as to help both the dorsal and lumbar curves (Figs. 245, 246, 247 and 248).

Mechanical Correction.

The mechanical methods which are used to reduce or remove the deformity are: (1) To limit, prevent or check faulty attitudes, (2) to exert pressure

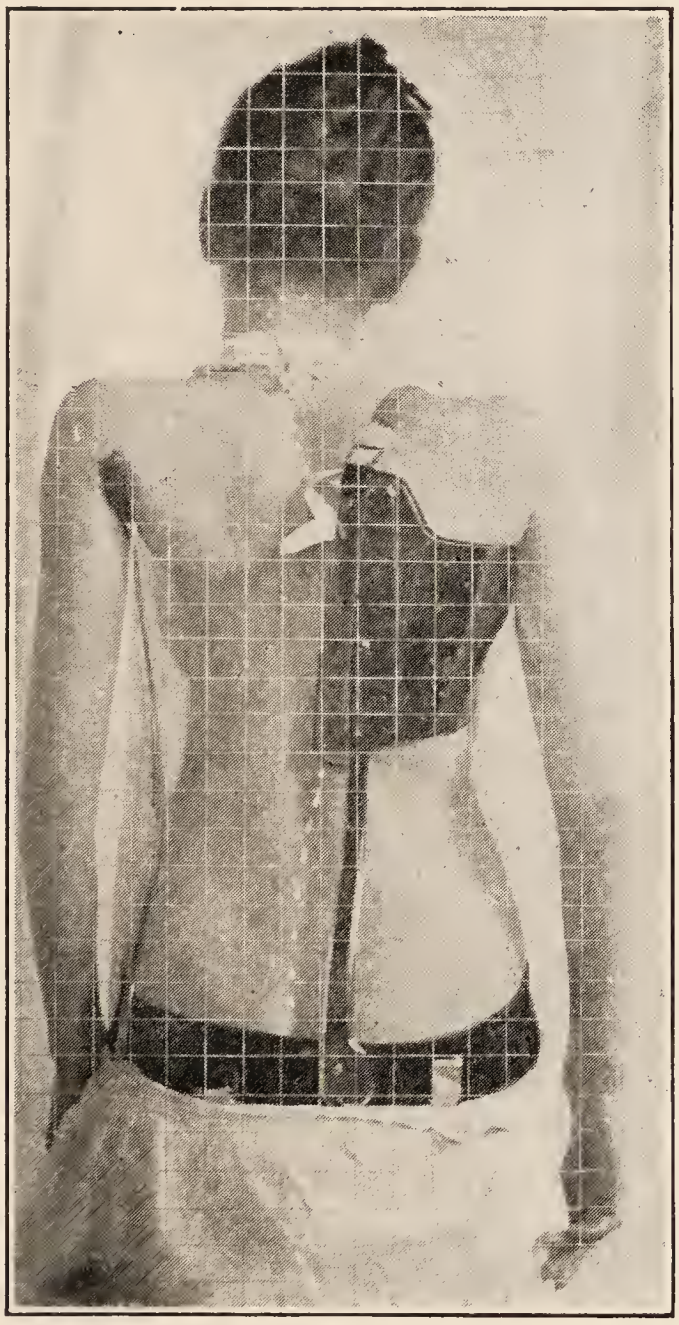


FIG. 254.—The author's steel scoliosis brace. Patient same as seen in Fig. 226.



FIG. 255.—The author's steel scoliosis brace

over projecting ribs, shoulder or hip, and (3) to untwist the rotation and curves of the spine.

1. To limit, prevent or check faulty attitudes, elevation of one shoulder simply or even a flexible spinal curvature may be corrected by a strap passing around the shoulder on the side of the convexity, then down across the back to the opposite hip, where it is attached to a belt, which in turn is fastened to drawers or stockings or special thigh legging or perineal straps. A simple device of this kind was made of webbing and surgeon's plaster by the writer to

over-correct the deformity in flexible cases as far as possible[1] (Figs. 250 to 253). He has found it the most useful form of light support and it is based on Wolff's law, and must be worn constantly except when doing routine gymnastics. If the other shoulder is lowered as well, a crutch may be attached to the belt to support it. Tilting of the pelvis or a lumbar curve should be helped by a tilted seat or a pad worn over the buttock of the convex side in sitting or if one leg is short raising the sole of that shoe for walking and standing (Fig. 249).

2. To exert pressure over projecting ribs, etc., various forms of braces have been used, utilizing the principles of tight straps, screw power and leverage, the last two, however, are not much used now, on account of their weight, which is an objection which will at once be apparent in a growing child already weak.

The Steel Scoliotic Brace.

The author devised and published the following scoliotic steel brace. A steel pelvic band is made with double perineal straps and has a steel upright extending up to the rotated ribs against which an adjustable plate attached to the upright presses. This upright by means of a ratchet arrangement and set screws could be moved inward to exert more pressure on the laterally deviated trunk or vice versa. With bending irons the forward pressure against the projecting ribs could be increased by the spring force of the steel. On the front of the pelvic band at a point diagonally opposite the posterior upright, an anterior upright and pressure plate was similarly adjusted to afford counterpressure against the projecting ribs. An axillary crutch attached to the pelvic band was sometimes found useful to support the low shoulder. This brace will be found useful in larger children in flexible and partially flexible curvatures in conjunction with gymnastic treatment[2] (Figs. 254 and 255).

The Corrected Plaster of Paris Jacket.

In the more severe flexible and partially fixed cases nothing will be found as useful as a removable plaster jacket made over a corrected plaster image of the body. This method was first suggested by Bartow and modified by Bradford and Brackett.

The method now used at the Kernan Hospital for Crippled Children consists briefly in measuring the circumferences of the thorax at axillae and bust, waist and pelvis of the patient; then the distances of the mammae from the anterior superior spines. The patient then sits on a table to flex the thighs and overcome the lordosis as much as possible, a head-sling is put on and the spine is stretched; the arms are supported to be on a level with the shoulders and if much lateral leaning or twisting of the trunk exists efforts are made to correct these by position as much as possible or by pressure rods in the Hoffa machine (vide infra). Over a suitable undershirt, without felt padding, a plaster jacket is applied, which when dry is cut off and used as a mold and filled with semi-liquid plaster of paris. This when set gives us a duplicate of our patient.

[1] Taylor, Amer. Jour. Ortho. Surg., Jan., 1905.
[2] Taylor, N. Y. Med. Jour., Oct. 30, 1897, vol. lxvi.

A line is drawn joining the posterior superior spines and upon the centre of this is drawn a perpendicular line which should be the line of the spinous processes. If the trunk is found to lean markedly to one side, the inclination is determined with the vertical and a reverse or over-corrected inclination is marked on the plaster for the future corrected cast.

With a carpenter's draw knife the plaster cast is cut away on the side of the

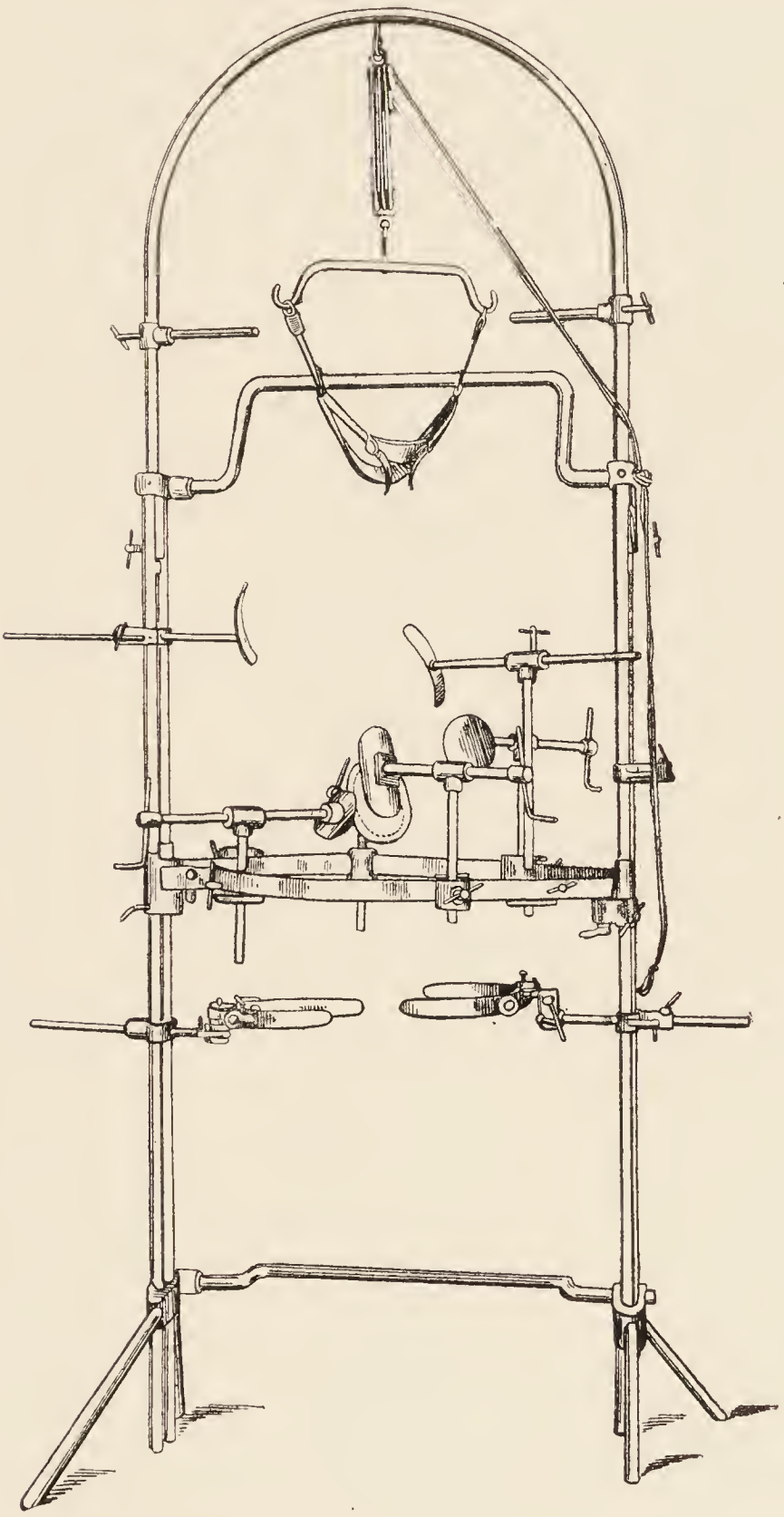


FIG. 256.—Weigel-Hoffa scoliosis machine. (*Young.*)

convexity, both in regard to lateral lean and rotation, front and back, and built up with semi-solid plaster of paris on the concavity by wetting the set cast previous to its application. Additional plaster is put over the mammae and anterior superior spines. The whole is then smoothed, sandpapered and shellaced.

Comparison is then made with the original measurements of the patient and if found to correspond, a plaster jacket is made on this corrected cast over an undershirt with felt pads over the anterior superior spines. When dry it is cut down the front, removed and finished with an outside covering of stockinet

and lacing, after thoroughly baking to remove all moisture and render as light as possible (Fig. 25).

Such a jacket, when worn by the patient, acts as a constantly correcting force to lessen lateral leaning and rotation. It should be worn all the time except when going through the gymnastics.

The author's experience with celluloid jackets made in this manner is unsatis-

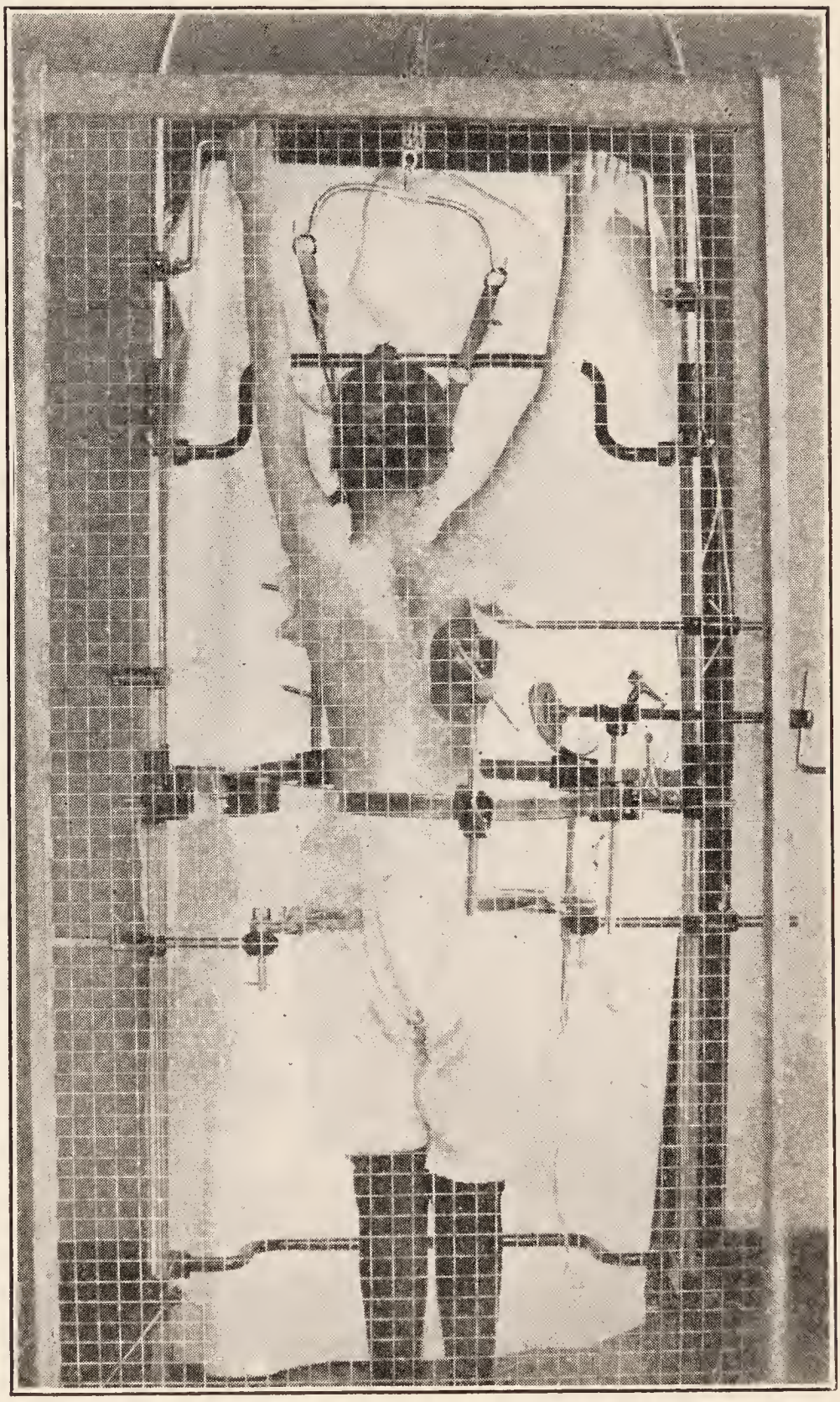


FIG. 257.—Weigel-Hoffa scoliosis machine applied to patient seen in Fig. 226.

factory in that they twist out of shape, are very tedious and expensive to make and are hot even when well perforated with apertures.

The enameled paper jackets as advocated by Weigel and made over the corrected casts are too hot for the southern climate aside from their expense.

The same may be said of leather jackets and Phelp's aluminium corsets.

When a patient gets a very expensive jacket she is unwilling to discard it when further improvement prompts the surgeon to further correct the cast and

make a new and more nearly normal jacket. So that in the long run a light, laced, cool and comparatively inexpensive plaster jacket is the best, in the author's judgment.

There are those who maintain that no brace, corset or support should be applied in scoliosis as weakening the muscles and others hold and can show by the advantages clinically, that it is essential and mechanically sensible to hold a deviated spine as erect as possible by day and night for the more it leans to one side, the greater to a certain extent will be the tendency of gravity and pathological function to increase the deformity, but the muscles must be taken care of in these cases by having the patient do her exercises twice daily vigorously, without the jacket and have massage to the entire trunk if possible.

3. The machines used to untwist the rotation and curves of the spine are:

(*a*) The Hoffa twister, which has the newest modifications as suggested by Weigel and Bradford and differs considerably from Hoffa's original. It consists of a steel arch, a head-sling and adjustable hand supports, with pads for screw pressure to be exerted over the ribs and clamps for the hips. Hoffa's newest modification has a seat to overcome lordosis and raise either side of the pelvis desired. By means of this daily in a standing or sitting position from 15 to 30 minutes in each case, pressure should be exerted to correct the lateral deviation of the spine and untwist the rotation of the ribs. It is of more value, however, as a machine to hold the correction, while a plaster jacket is being applied for forcible correction and not to be removed or made for lacing (Figs. 256 and 257).

(*b*) The modified Lorenz roller is a padded roller on which the prominent ribs of the patient's back rests as she stands on the floor, the arm of that side surrounds the roller and the hand of the concave side grasps a bar, which can be moved by a crank and raise the patient from the ground, causing the weight of the entire body to exert pressure on the prominent ribs against the padded roller. By lying with the prominent side on the roller, the spinal curve can be temporarily straightened and the shortened ligaments stetched daily (Fig. 280).

(*c*) Riely's modification of Beely's pressure machine consists of two padded supports for the upper thorax and pelvis on which the patient rests face down with the thighs flexed at right angles with the trunk to lessen the lordosis. A strap passes over the rotated ribs at the point of greatest curvature, one end of the strap is made fast to the wall and on the other hooks are provided to put weights on up to 100 pounds, which is often not found too much pressure for these cases. By raising the wall attachment of the strap greater correction is effected in the lateral curvature and by lowering it the rotation is chiefly reduced.

In Beely's machine, the patient's trunk is unsupported save by the arms and legs and fatigue is much sooner experienced (Figs. 278 and 279).

These machines may be employed in the daily routine exercise of treatment, with benefit.

Forcible Correction.

Certain cases of moderately severe grade are best treated by solid plaster of paris jackets put on in some machine which can effect more or less forcible correction. This can be done in the Hoffa machine or either of the two following.

By this means if these jackets are changed every two or three weeks, a progressive stretching of the contracted ligaments and muscles may be effected and if per-

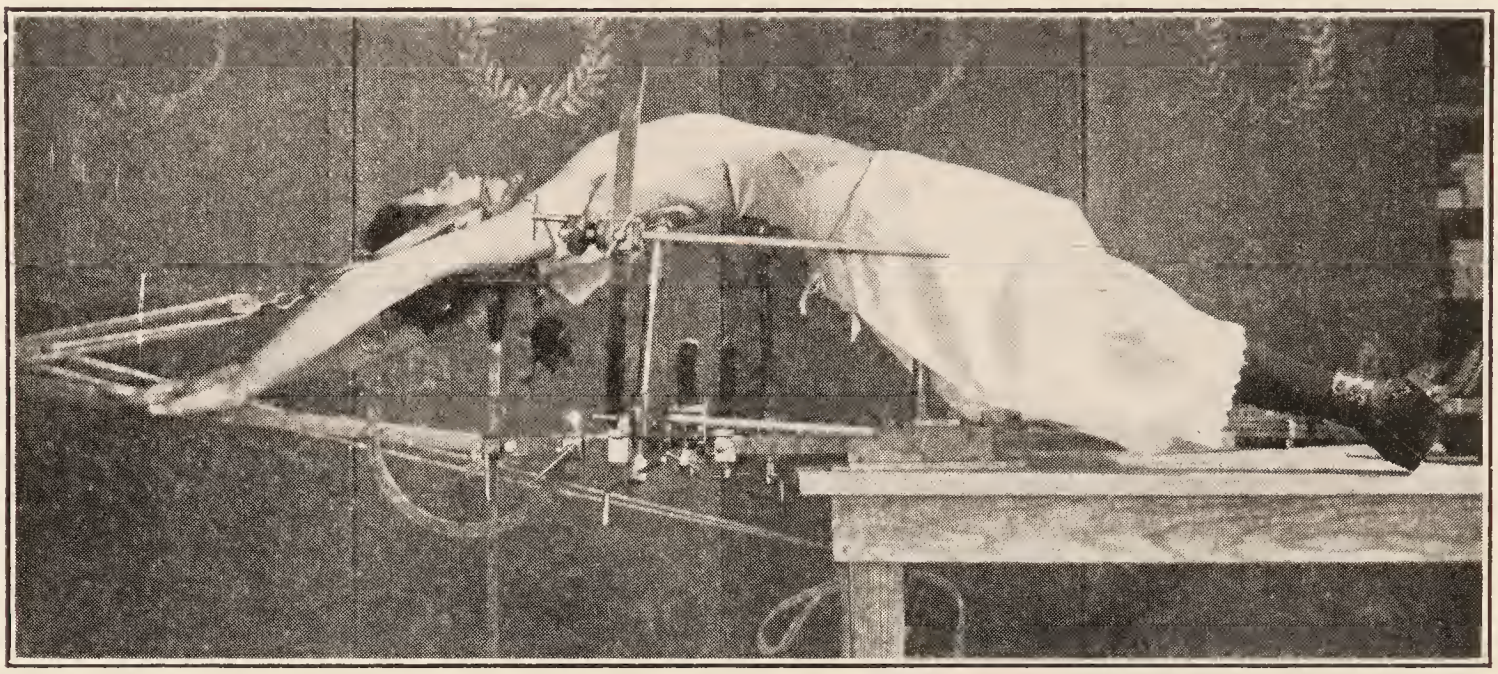


FIG. 258.—Author's scoliosis correction machine.



FIG. 259.—Patient shown before application of forcible correction.

sisted in for a sufficiently long period the bones too will undergo functional transformation. Later gymnastics, massage and the wearing of removable plaster jackets made over a corrected cast will accomplish much.

(*e*) The writer's machine[1] is a modification of the large supine recumbent kyphotone, with the addition of hemispherical arcs to which are attached screw pressure rods and plates similar to those used in the Hoffa machine (Fig. 258).

The pelvis is supported by a crutch and the thorax by the lateral and diagonal antero-posterior pressure rods. Traction on the head is made by the ordinary head-sling and double pulleys, the hands grasp the hand rods and the

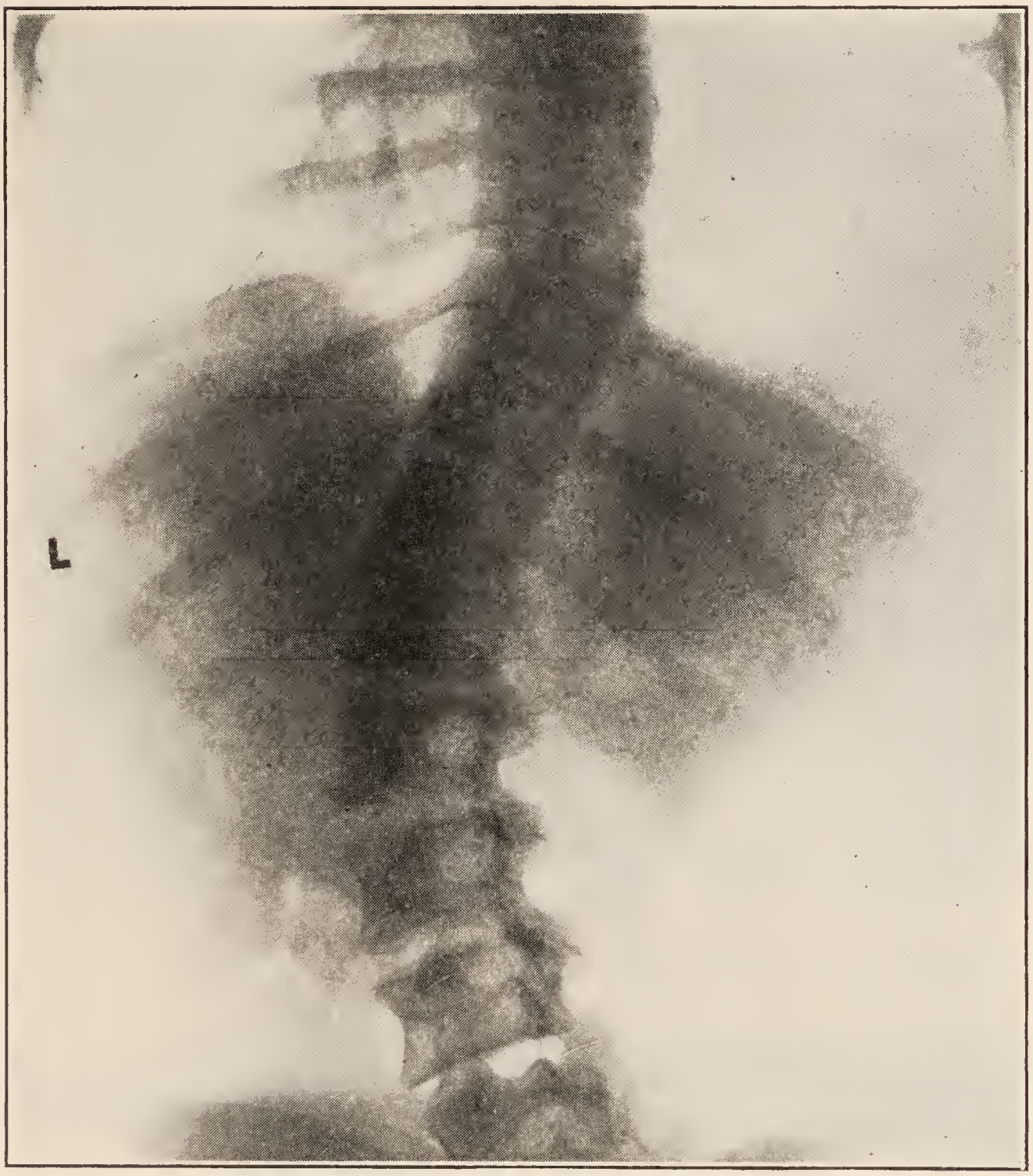


FIG. 260.—X-ray of patient shown in Fig. 259 before application of forcible correction.

legs are made fast to the stirrups. Then as much forcible correction as possible is made by the pressure rods and traction, and a corrective plaster jacket is applied (Figs. 259, 260 and 261). Compare Fig. 37.

(*f*) In certain instances as demonstrated by Lovett in his experiments[2] more correction by side pressure can be obtained by *not* using traction on the spine, just as one could bend a stick more readily if traction, which resists the lateral forces is not made on the two ends.

[1] Johns Hopkins Hospital Bull., Feb., 1895, No. 45.
[2] Boston Med. and Surg. Jour., Mar. 17, 1904.

Lovett's experiments were made with flexible rods, cadaver and healthy living subjects and in each the side pull was more marked without traction than with it.

On these facts the Lovett-Adams machine was constructed. It consists of



FIG. 261.—Patient shown in Fig. 259, after correction in author's machine and application of plaster jacket.



FIG. 262.—Lovett's scoliosis table showing curvature in patient before lateral traction is made.



FIG. 263.—Pulley traction for stretching. The axilla and pelvis are fixed on the right side of the table. A double pulley at the head of the table tightens the central strap by means of a pulley shown on the left side of the table.

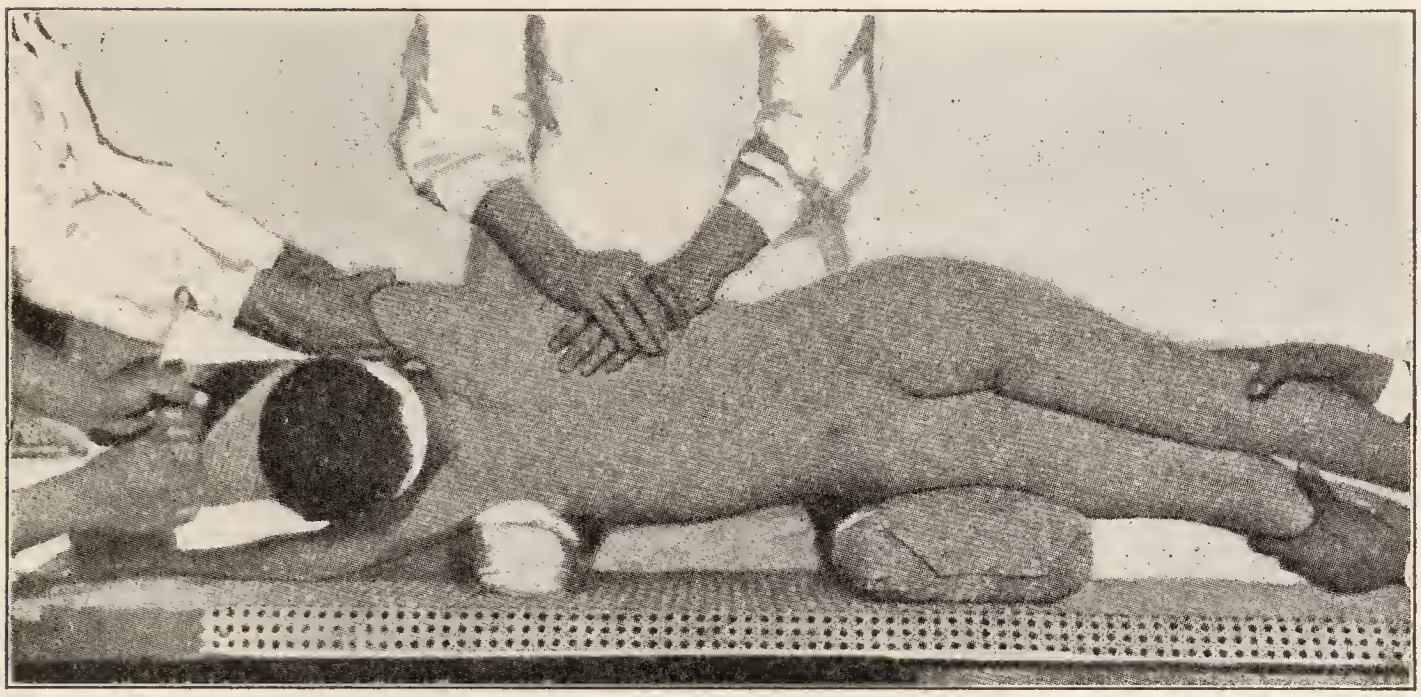


FIG. 264.—Manuel correction of scoliosis. (*Redard.*)

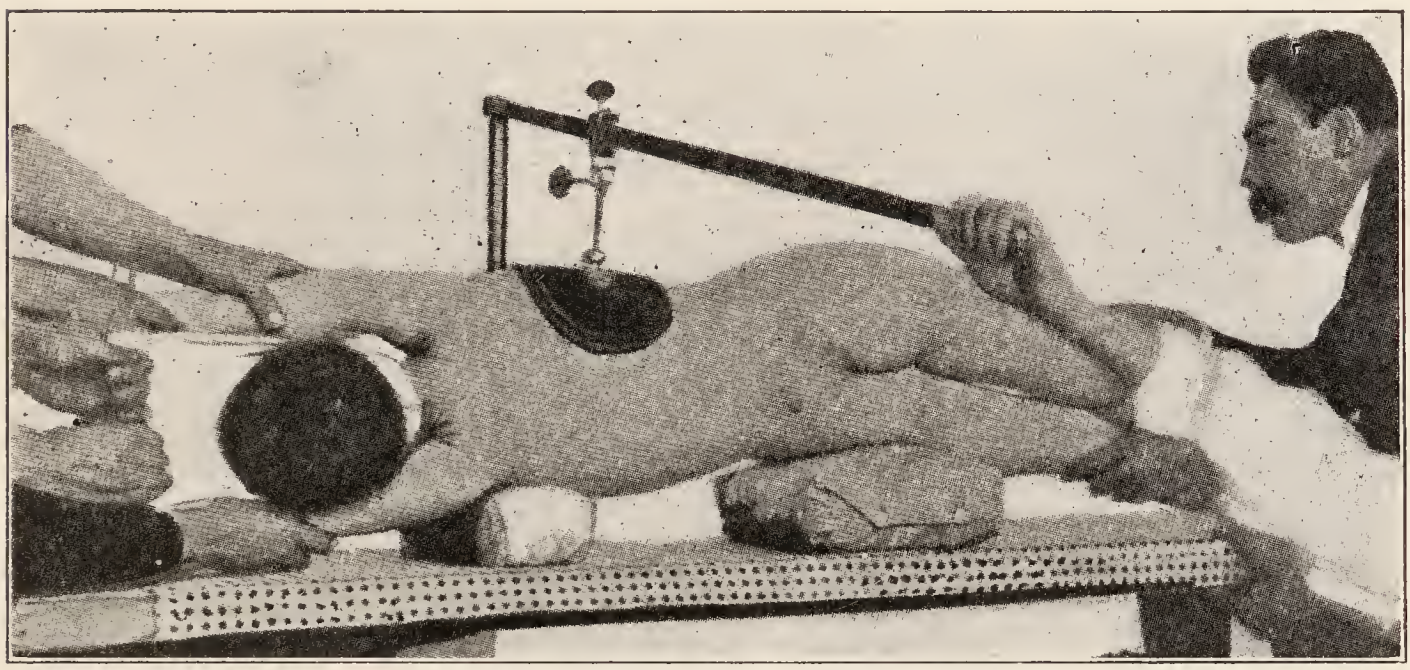


FIG. 265.—Lever correction of scoliosis. (*Redard.*)

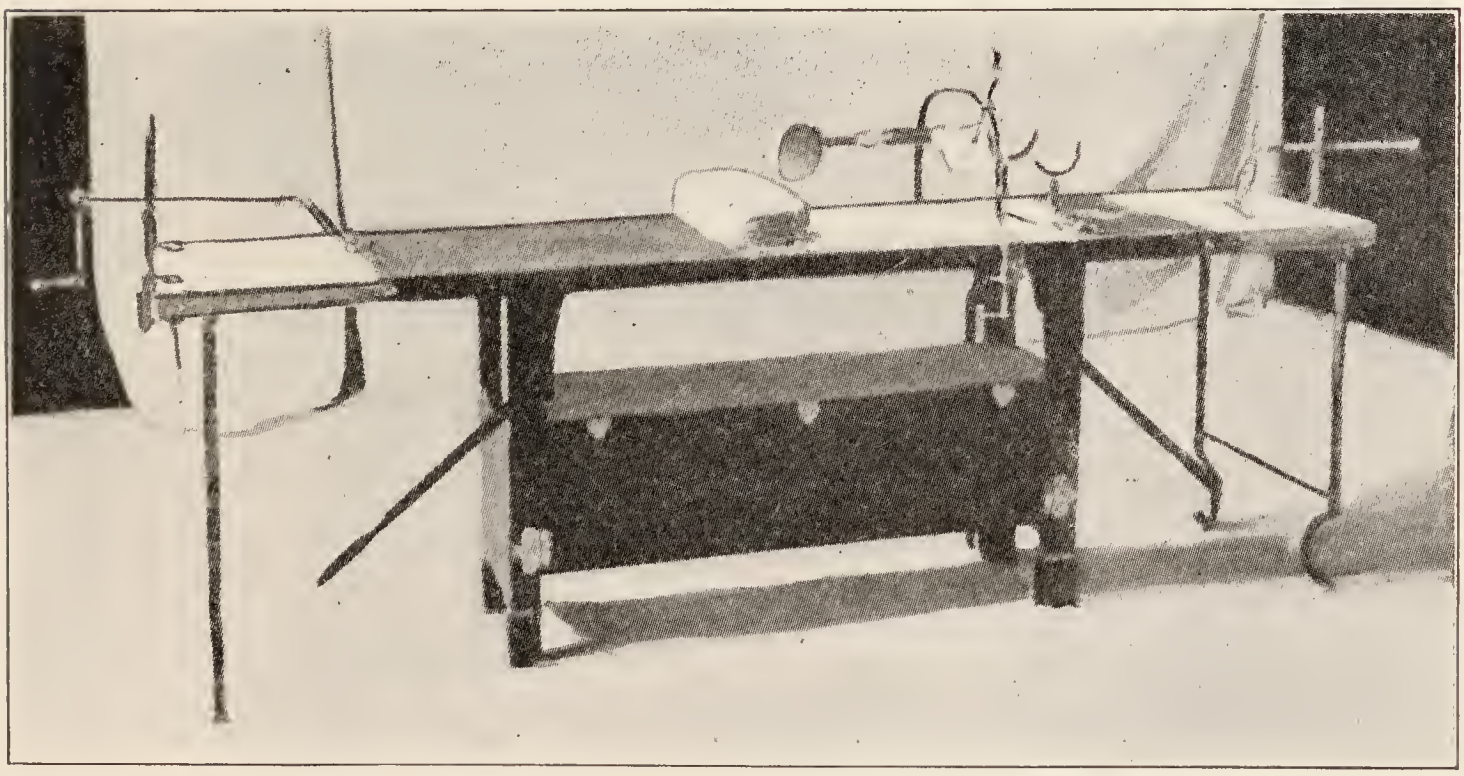


FIG. 266.—Frame for forcible instrumental correction of scoliosis. (*Redard.*)

a pelvic support and clamps; the body is prone and thighs are at a right angle to the body, which is surrounded by three double circles with two pressure rods each, on each central circle, which may be made to rotate or not, by a set screw on the outer circle.

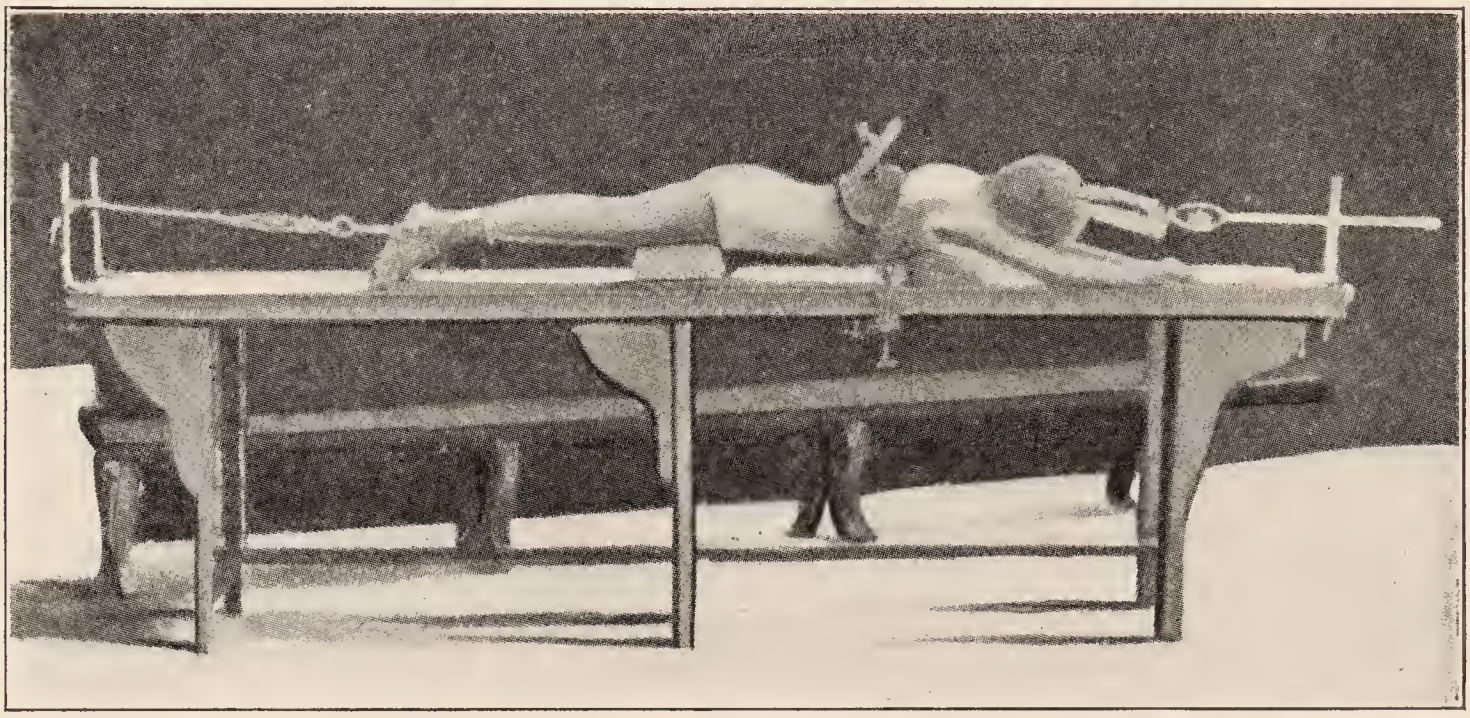


FIG. 267.—Same showing application of pressure and plaster cast. (*Redard.*)

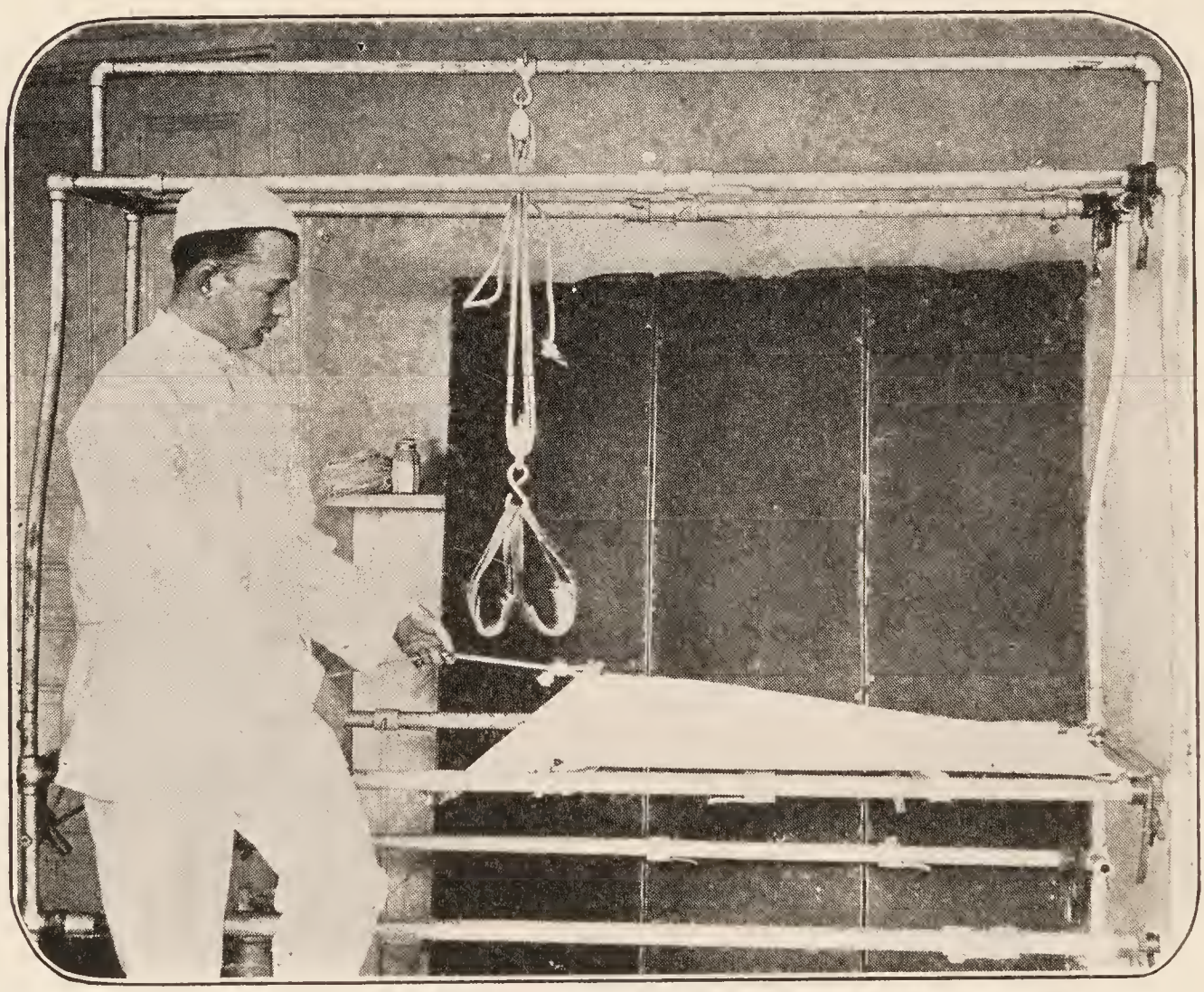


FIG. 268.—Abbott's scoliosis correcting frame. The trapezoid shaped hammock.

The pelvic support and circles rest on a gas pipe frame.

Pressure is made directly and not obliquely on the lateral inclination of the trunk and rotation of the ribs or the lateral inclination is corrected by lateral movement of the entire circular segment on the gas pipe frame; then the deformed

spine is derotated in the desired direction at the three different segments by moving the circles. When the desired degree of correction is obtained a fixed plaster of paris jacket is applied. Such a jacket is worn two weeks then removed, and more correction tried and so on. Later the same after-treatment is employed as with the Hoffa machine. In upper dorsal and cervical scoliosis traction must be used and the head and neck included in plaster or some steel brace or jacket and jury mast employed (Fig. 155).

(*g*) *Table and Strap Pulley Machine.*—This simple piece of apparatus was devised at the Children's Hospital, Boston, and is based upon Lovett's experiments also (Figs. 262 and 263).

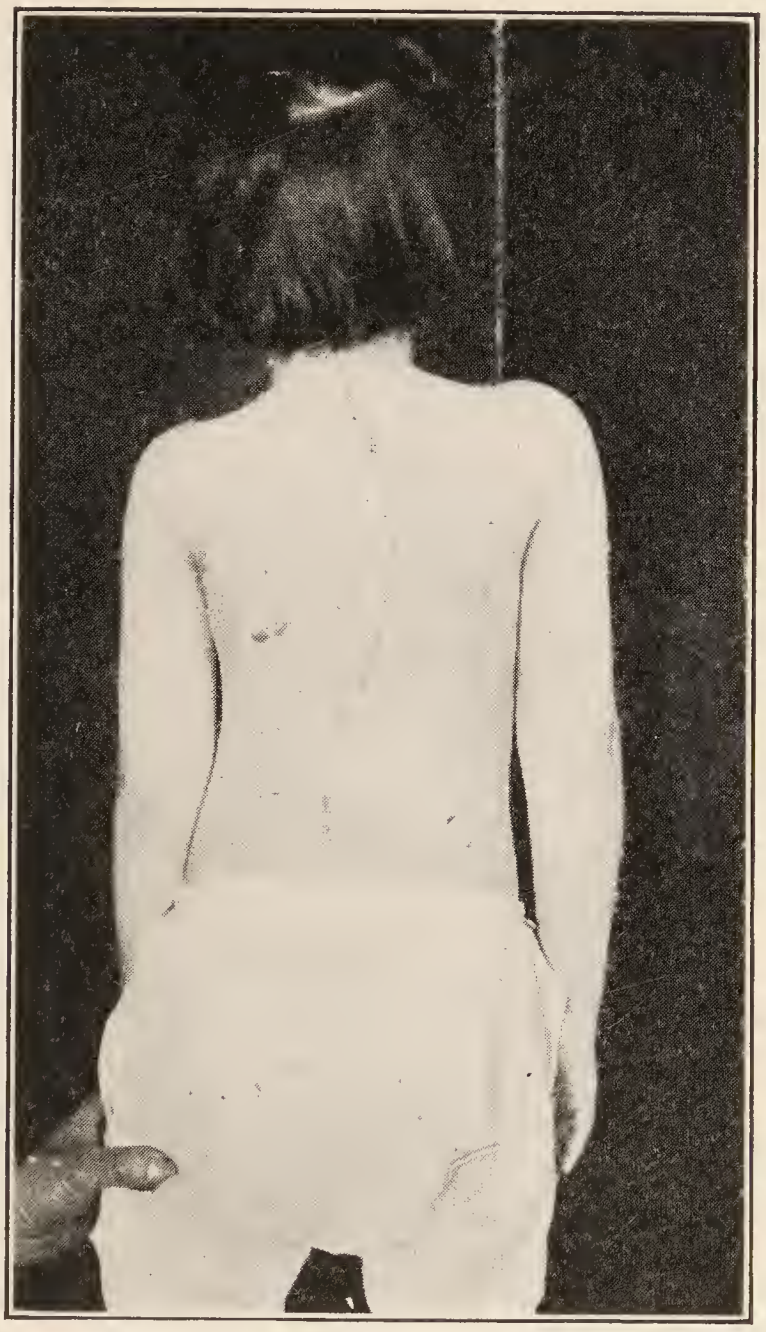


FIG. 269.—Patient before application of plaster jacket on Abbott frame.

It consists of an ordinary kitchen table into the centre of one end of which is screwed a hook to which is attached a compound pulley. On the sides at the opposite end are four or five cleats at intervals.

The patient kneels on a stool at this end and the trunk lies prone between the two rows of cleats. By means of an encircling webbing strap and attached cords the pelvis is made fast to a cleat on the side of the maximum convexity. In the same manner a strap makes fast the highest part of the thorax under the axillae when the arms are fully extended upward. On the side of the concavity a pulley is fastened to a cleat and a cord passes to the lower side of a strap which should encircle the trunk at this point, the upper side of which is made fast to

a cleat near the pulley. The cord which passes through the pulley goes to the lower one of the compound pulleys. By a cord from the upper compound pulley the patient or gymnast can not only effect lateral correction of the curvature, but derotation of the trunk as well in flexible and partially flexible cases.

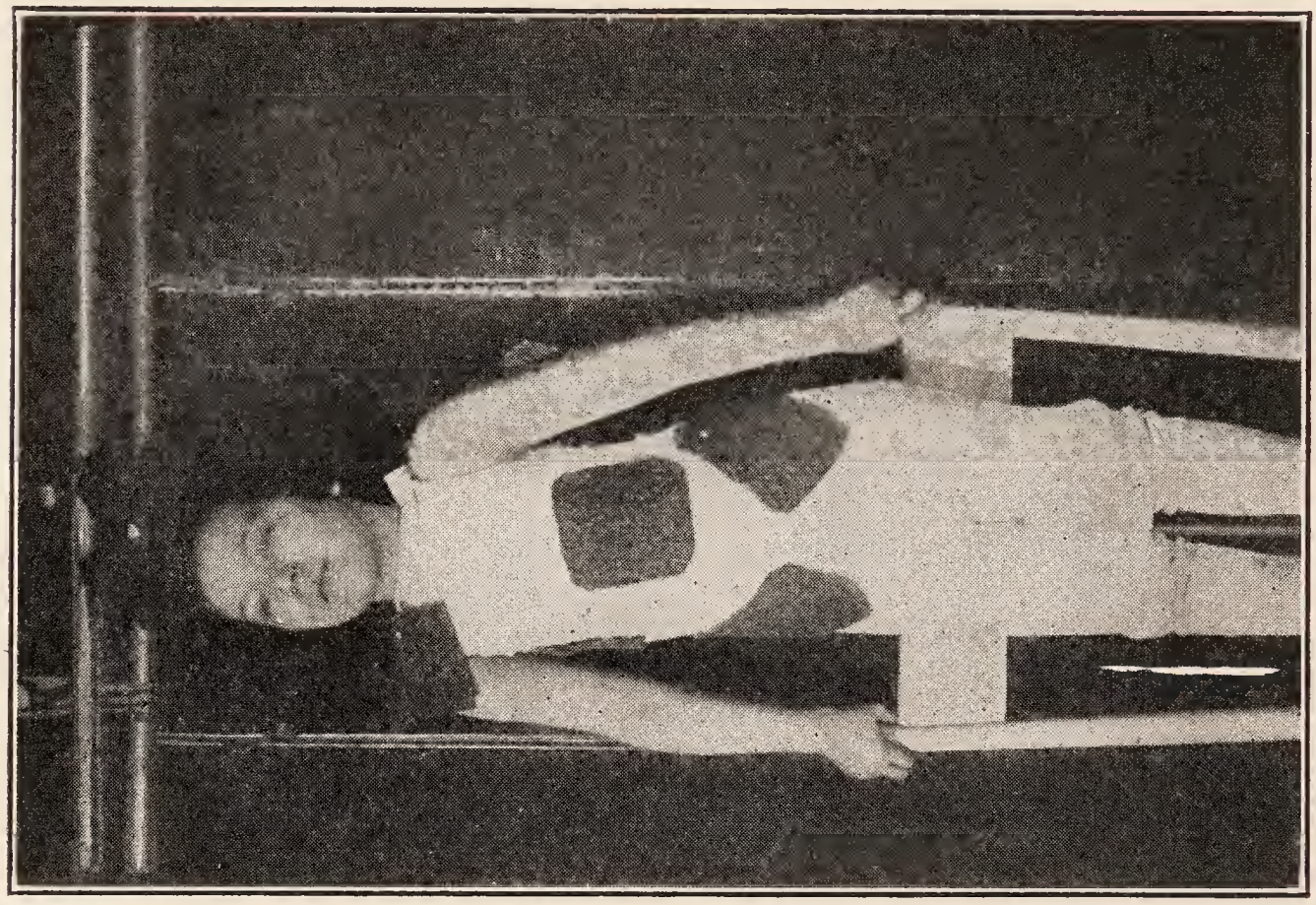


FIG. 272.—Padding on patient preparatory to application of Abbott jacket, front view.

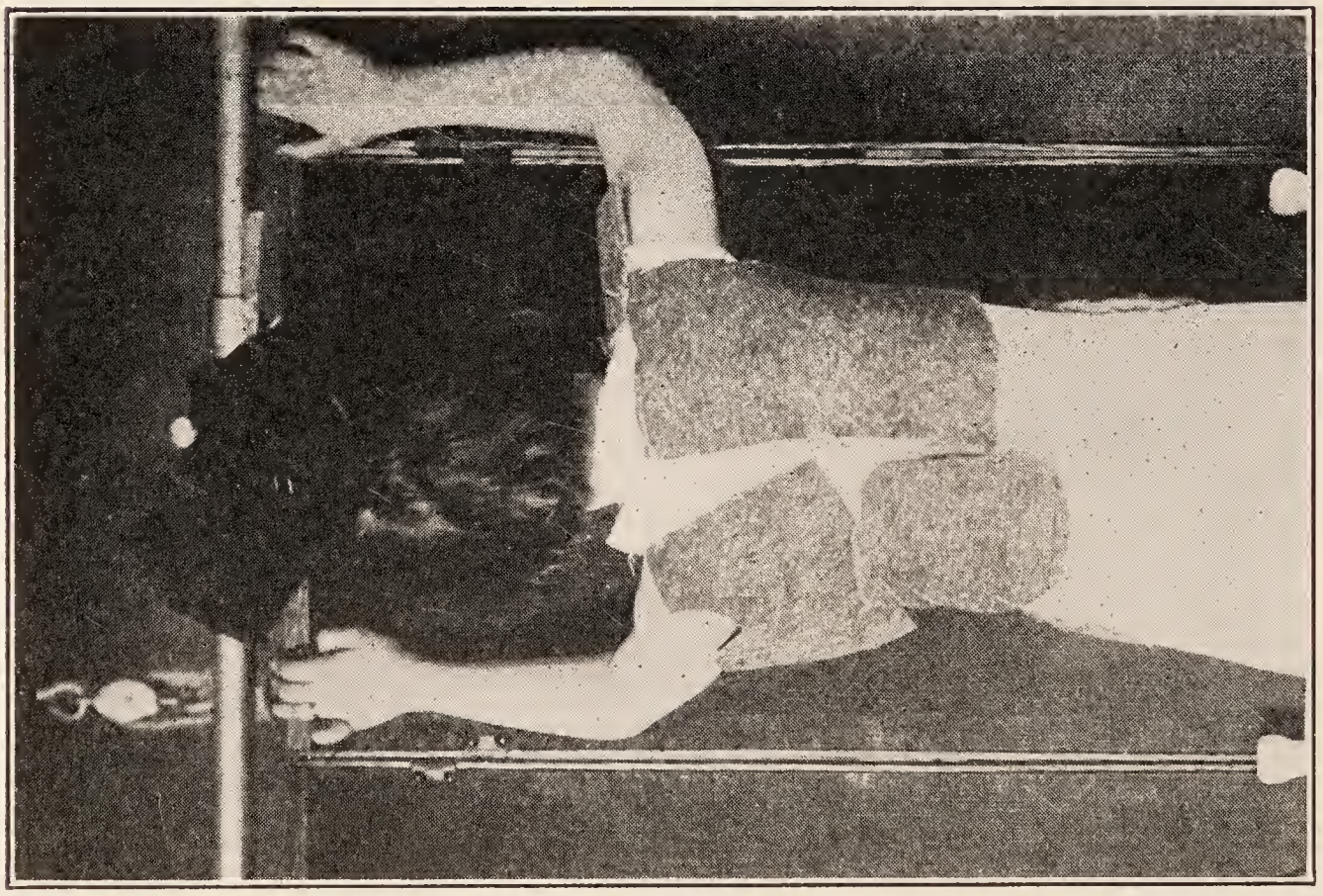


FIG. 270.—Padding on patient preparatory to application of Abbott jacket, back view.

We also use a segmented table devised by Lovett with a central axis and straps arranged very much as in the above apparatus and it posseses only the advantage that the segments may be rotated with the aim of untwisting the spine and has rachetted pressure pads for lateral and posterior curves.

These last two machines, however, are used only for daily routine correction and not as a means of obtaining correction while a plaster jacket is being applied.

Redard has done much work in forcible correction (Figs. 264, 265, 266 and 267).

The Abbott Correction of Lateral Curvature.

In the New York Medical Journal of April 27th 1911, appeared a preliminary

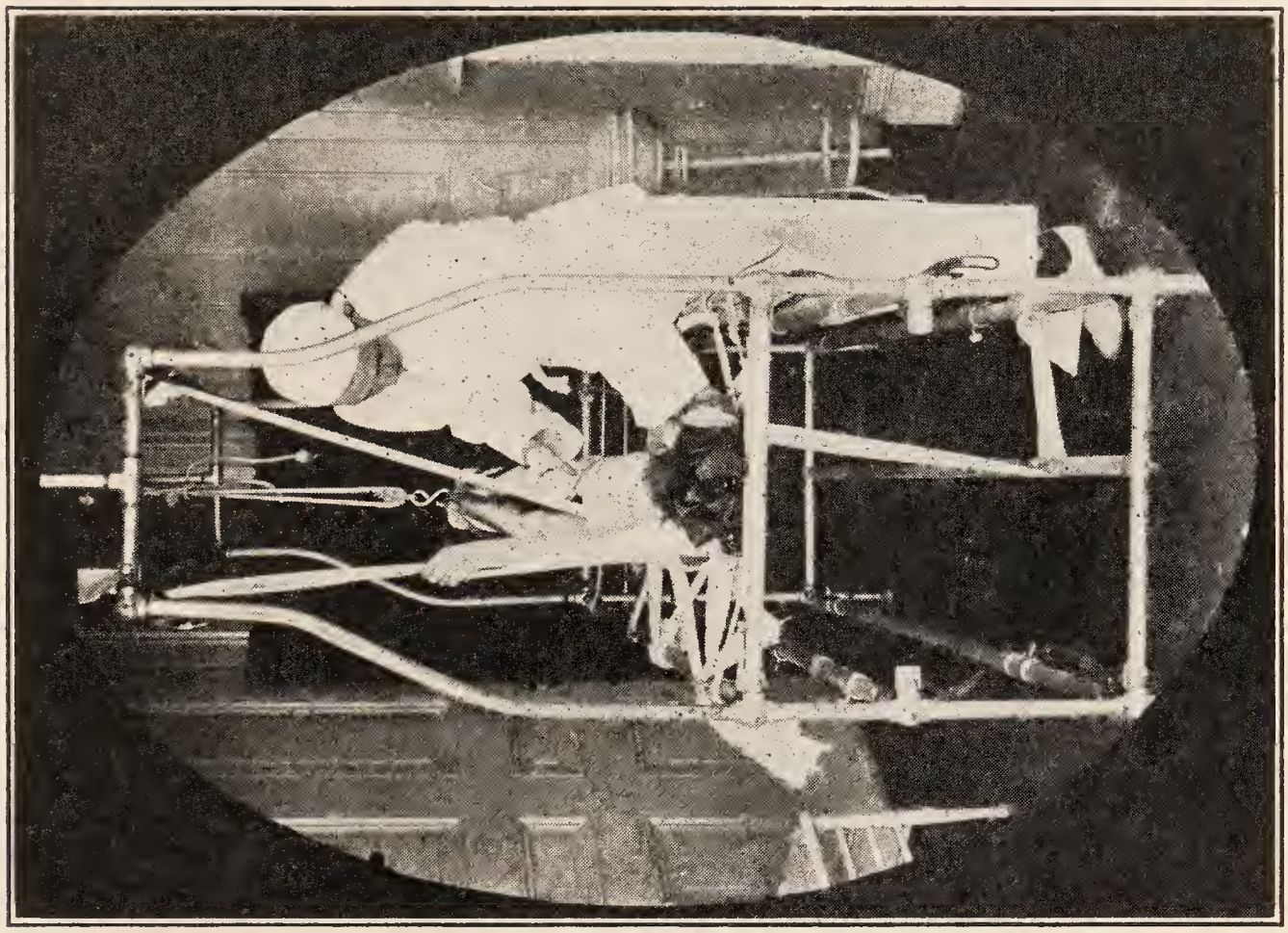


FIG. 273.—Arrangement of traction straps for correction by Abbott method.

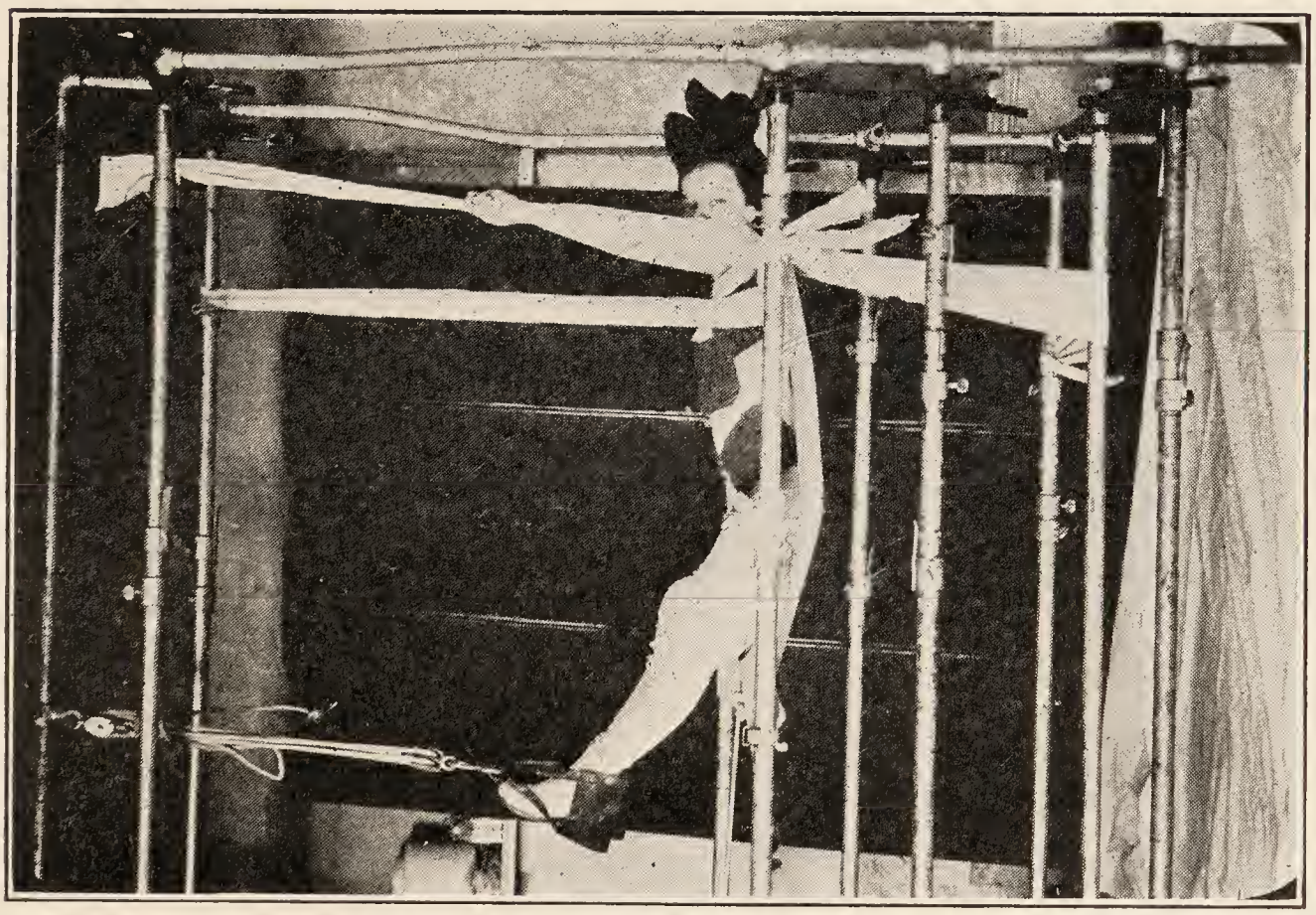


FIG. 272.—Arrangement of traction straps for correction by Abbott method.

article by E. G. Abbott of Portland, Maine on the "Correction of Lateral Curvature of the Spine" and subsequently in the same Journal of June 24th 1912 appeared his article on the "Simple, Rapid and Complete Reduction of Deformity in Fixed Lateral Curvature of the Spine."

His study and research in the problem had been extensive and his published results were amazing, especially as hitherto in severe fixed cases most surgeons had been well satisfied with slight improvement in this deformity or even with preventing it from getting worse (Figs. 268, 269, 270 and 271).

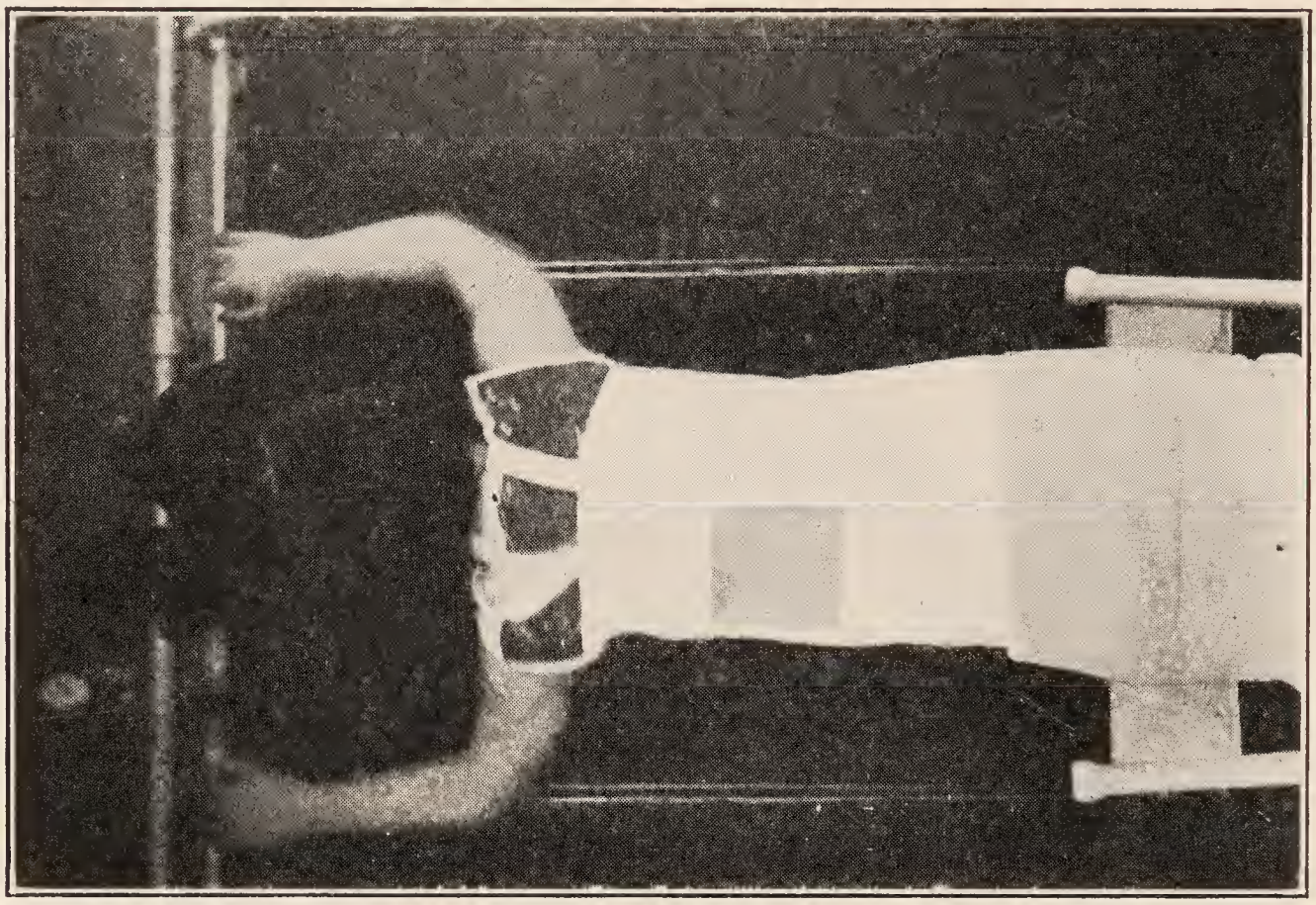


FIG. 275.—Back view of completed jacket. In this case, it was not necessary to include the shoulders in the cast. Note back "window."

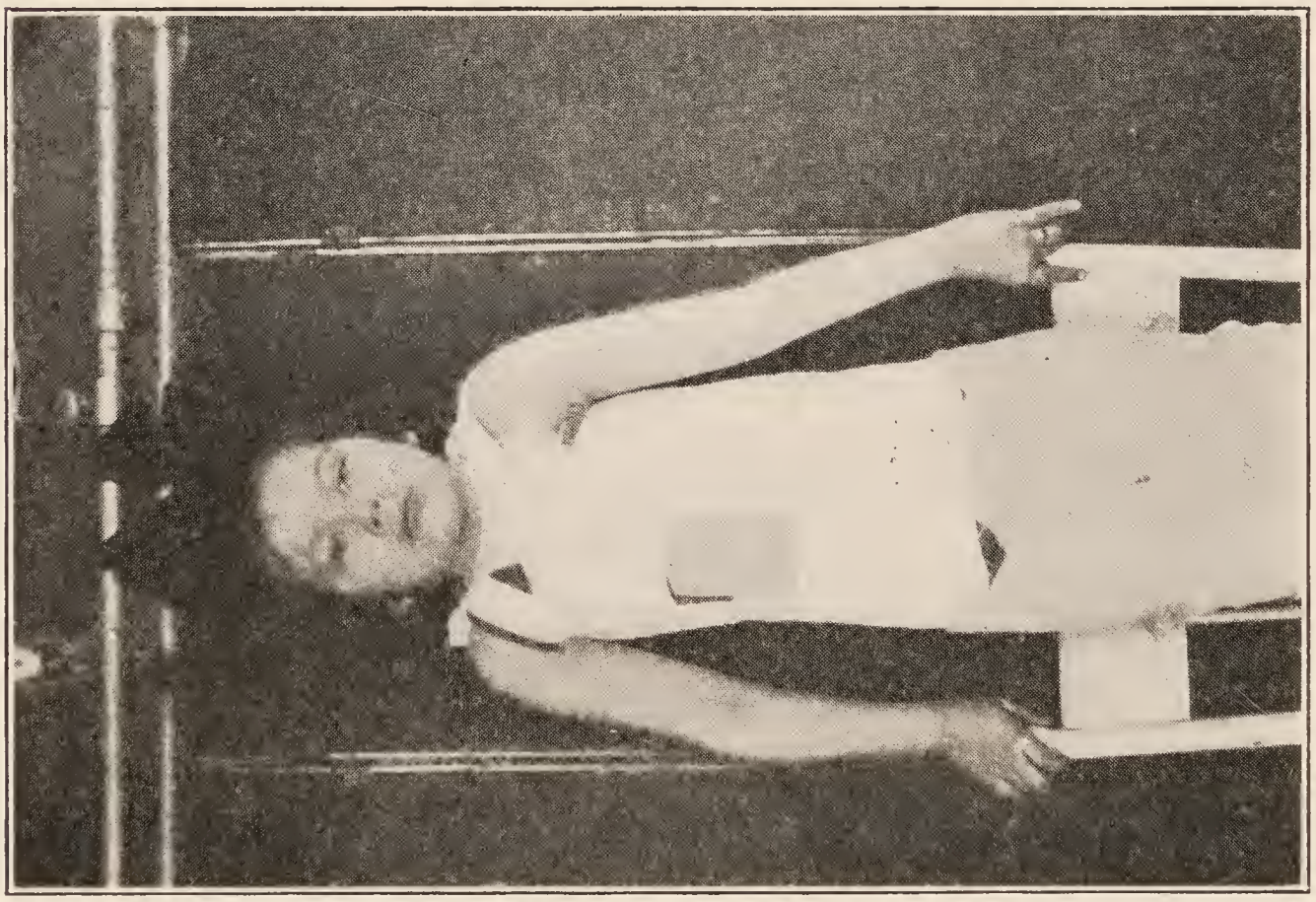


FIG. 274.—Anterior view of completed Abbott jacket used in this case with "windows."

He based his study upon what might be called a reversal of the factors that brought about the deformity namely a sagging of the trunk *when flexed* to one or more sides with the corresponding carrying of one shoulder backward and the other forward. He even went so far as to produce a fixed curvature in a normal student and then over-corrected it in the opposite direction and then restored it to normal again by means of a series of plaster jackets put on with

the spine extremely *hyper-flexed* at the points of deformity. He demonstrated that when the spine is extended or hyper-extended the articular processes locked



FIG. 276.—An extremely severe case of scoliosis from infantile paralysis sufficiently flexible to permit correction and a bone fusion operation by the Hibbs or Albee method or a combination of the two.

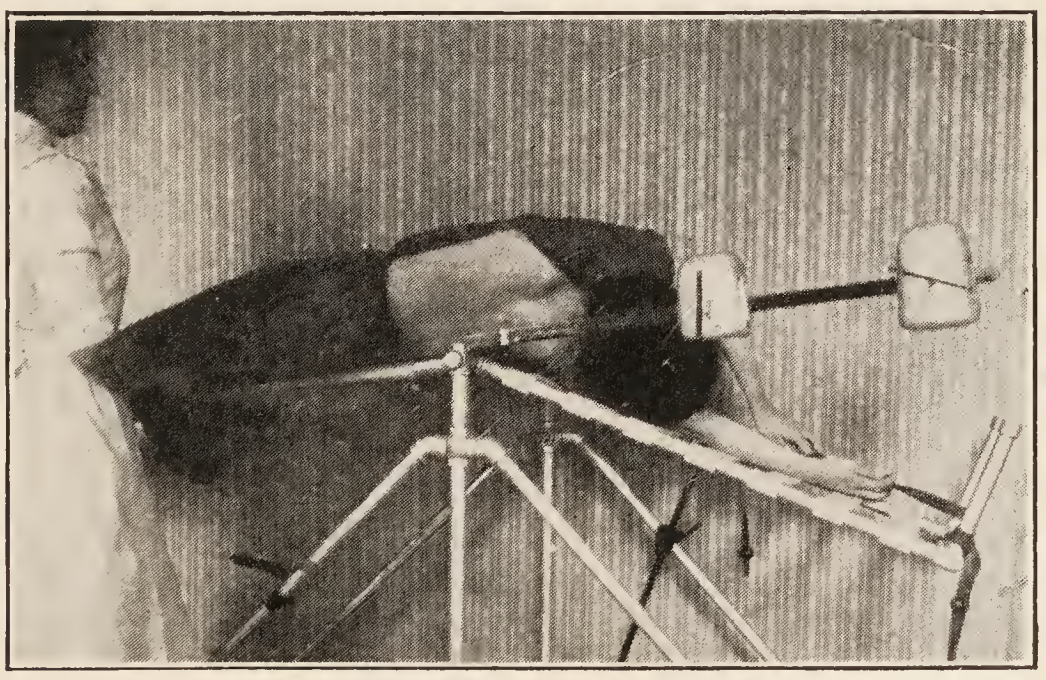


FIG. 277.—Zander Rocker being used for right dorso-lumbar scoliosis.

and this explained in some instances why previously clinicians had failed to help the cases more. He also showed how the rotation could be overcome at the same time by cutting large windows over the concavities to allow the

ribs to rotate into them and placed additional pads of felt from time to time over the convexities both lateral, anterior and posterior to push the deformity

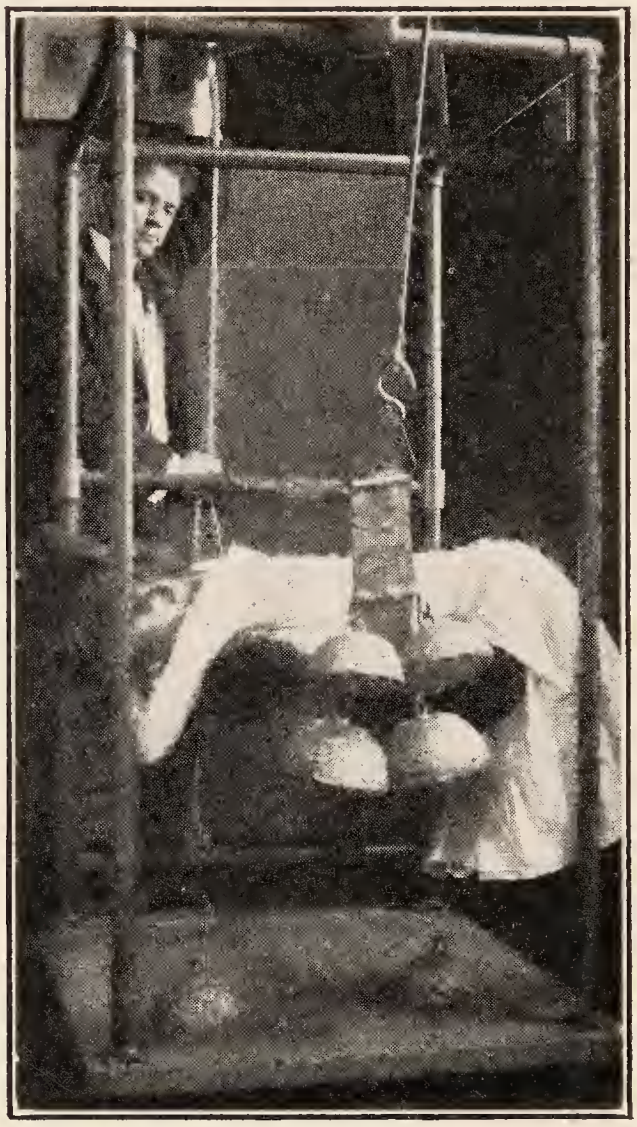


FIG. 278.—Riely machine. 40 pounds suspended on strap being lowered to derotate and exert lateral pressure on left dorsal scoliosis.



FIG. 279.—Riely machine. Pressure exerted in right dorsal scoliosis. Note padded buffers at patient's left axilla and left pelvic region.

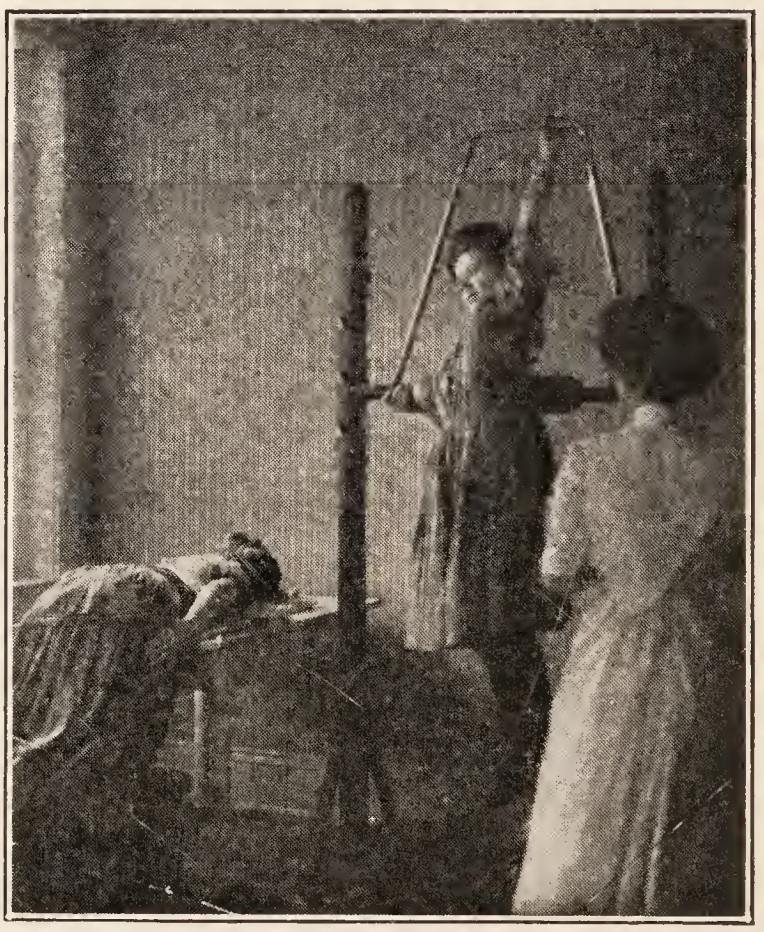


FIG. 280.—Lovett table and Lorenz roller in use. Gymnast is pulling lever in latter that carries patient's left arm upward, lifts her off the ground and causes pressure on right side.

into place or even over-correct. Putting on two stockinet shirts facilitates introduction of felt between them. He found this application of jackets coudl

not be done with the patient erect and was best done in recumbency with the legs suspended and flexed on the body and weight resting chiefly on the bowed spine and shoulders.

The patient rested supine on a trapezoid shaped hammock held in a quadrilateral gas pipe frame with uprights and cross bars for the attachment of canvass straps to encircle the trunk and make lateral and derotation pressure and to pull the arms forward or backward as might be desired (Figs. 272 and 273).

The trapezoid hammock allows one side to be drawn tight and the convexity is supported on this side and little or no pressure is made on the concavity. To increase the flexed position and weight on the shoulders the lower legs of the frame should be raised.

The shoulders are included in the plaster jacket, in the reversed position to that in the deformity. These jackets are unsightly, uncomfortable and requires close hospital supervision as the pressure is so great that alarming syncope and dyspnoea sometimes ensue and fatalities have even been reported. Derotation and improvement in the lateral deviation are accomplished by felt padding introduced through special windows to facilitate this until over-correction is obtained. This treatment is followed by massage and exercises.

Abbott's method in detail is so radical and at times dangerous, that it has not been generally adopted, but theoretically it has many features to commend its cautious use by experts.

Summary.

The summary of treatment that may be employed is:

1. In incipient postural cases, where curves disappear with recumbency and suspension, postural treatment with preventive measures should be used.

2. When in addition to the above, muscular weakness and habitually faulty attitudes are present, corrective gymnastics must be used in addition.

3. In "flexible" curves that are becoming rapidly more pronounced, removable fixative appliances to over-correct the deformity, have practical as well as scientific value.

4. In partly "fixed" curves, where more or less muscular, ligamentous and osseous changes have taken place, daily methodical correction for several months or even years together with corrective gymnastics, suspension, recumbency and fixative strapping or jackets must be resorted to. The Zander, Riely and Lorenz stretching machines are also shown in the illustrations (Figs. 277, 278, 279 and 280).

5. In "fixed" cases that are not hopelessly deformed forcible correction is very helpful and may be obtained by means of the author's machine, the Hoffa twister, or the Lovett-Adams or Abbott apparatus when a fixed series of jackets are to be applied. Subsequently the case is to be treated as a partly fixed curvature.

6. In flexible paralytic cases osteoplasty is helpful (Fig. 276).

Daily corrective gymnastics are extremely valuable in all cases until ossification is complete. Prolonged recumbency at midday, with early retiring, late rising and a cold morning sponge bath should be insisted on for these relaxed girls.

The time required for treatment is in the growing years, in light cases with weekly, monthly, quarterly or semiannual inspections and instructions and in the severer and apparently increasing cases with methodical daily corrections by gymnastics, machines and fixative appliances.

PART III

AFFECTIONS OF THE EXTREMITIES

CHAPTER XVII

TUBERCULAR HIP DISEASE

Definition.

Hip disease is a chronic tubercular invasion of one or both bones of the joint beginning usually on the metaphyseal side of the epiphyseal line of the femur or in the epiphysis. It results in impaired function or ankylosis, or complete destruction of the joint or recovery, in the order named.

Synonyms.

Coxalgia; morbus coxarius; morbus coxae; caries of the hip; hip disease; tuberculous osteitis of the hip.

Frequency.

Coxalgia comprises about 10 per cent. of all orthopaedic cases.

Etiology.

The causes are (1) predisposing and (2) exciting.

The predisposing causes are dependent upon (*a*) age, (*b*) sex, (*c*) heredity, (*d*) hygienic surroundings, (*e*) social condition, (*f*) the exanthemata of childhood, (*g*) traumatism and (*h*) disease of neighboring organs. The exciting cause is the bacillus tuberculosis.

Predisposing Causes in Detail.

Age.—From 2 to 13 years is usually the time when this disease begins, although cases have been reported as young as one month and as old as 54 years.

Bone tuberculosis is more common in childhood than in adult life; probably from the imperfect vascular anastomosis in the epiphyses, during the growing period, and more constant activity with slight traumatisms furnishing a point of least resistance for bacterial lodgment and development.

Sex.—Statistics go to show that hip disease is slightly more common in boys than in girls, perhaps from their more active habits and the greater liability to trauma.

Phimosis was at one time considered another reason for the frequency of the disease in boys, but recent writers seem to consider this a mere coincidence, as many healthy boys present this condition of the prepuce and many cases of hip disease do not present a condition of phimosis. Some observers have similarly reported cases of vaginitis in females with hip disease, probably from the ease of infection in a child of lowered vitality. The mode of infection with the bacillus tuberculosis is more probably through the blood or lymphatic vessels from diseased mediastinal or abdominal lymph-nodes.

The right side is more frequently affected than the left in a small percentage of cases. In 132 cases recently seen at the Kernan Hospital for Crippled Children, 72 were on the right side.

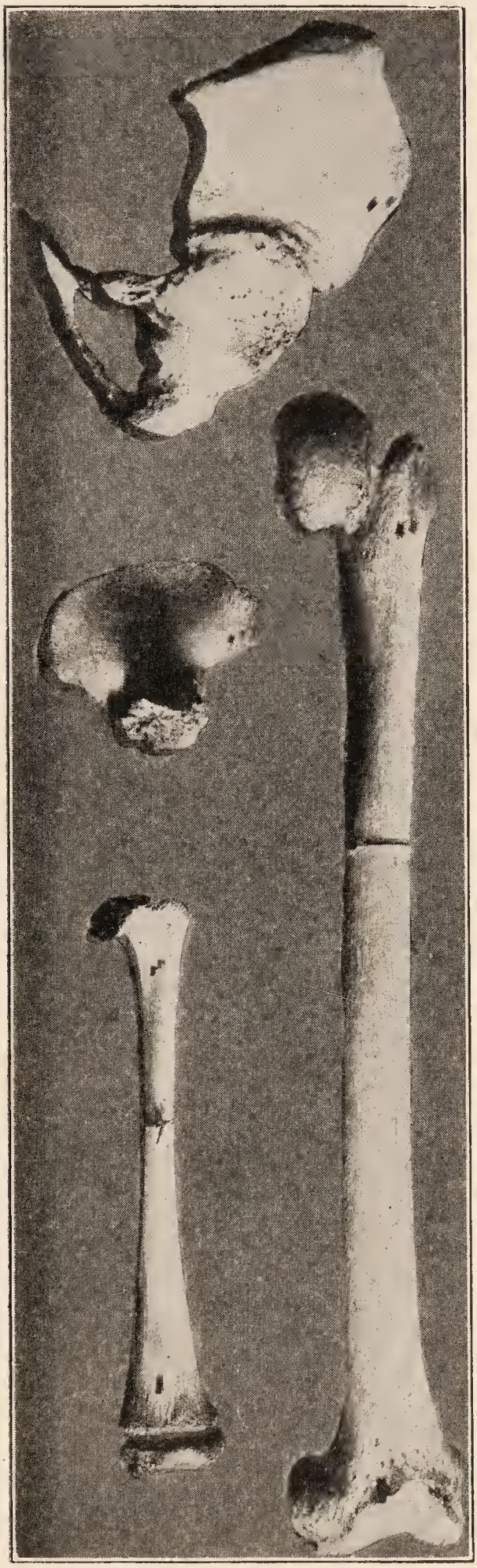


FIG. 281.—Tuberculous hip-joint disease. (*Wistar Institute of Anatomy. Young.*)

Heredity.—Tubercular family history plays an important role in the aetiology of hip disease, although some parents seem to endeavor to conceal such a "scrofulous"(?) tendency in ancestors and relatives and the majority blame some injury. Statistics are therefore inaccurate. Perhaps, however, in ¾ of the cases seen, heredity may be put down as a causative factor, not by direct intra-uterine transmission, however, but acquired through the respiratory organs from germ-laden dust of infected houses, or through the gastro-enteric tract from infected meat or tubercular milk, which may cause the variety of bone disease known as "Bovine Tuberculosis."

Pathology.

The remarks previously made in regard to the tubercular process in general in spine disease, apply equally to hip disease. But few cases of very early hip disease comparatively are fatal. Hence but very few of these cases have been examined post-mortem. The X-ray, however has thrown much light for us on the pathology at this period as well as later on.

Theoretically, any of the joint constituents may be primarily involved, but the bone is most frequently the site. However, the synovial membrane may be the origin, though rarely, hence the fallacy in general of injecting antiseptic solutions into the capsule of the joint. The acetabulum has never been recorded in any post-mortem, as the primary seat of this disease, but certain X-ray pictures seem to show it. The head and neck of the femur are the more common foci. One case is reported where the ligamentum teres at its attachment to the acetabulum and femur exhibited inflammatory redness, showing ligamentous origin.

The extent of the diseased process depends much on the power of resistance of the individual, the extent of the initial lesion and the virulence of the invading bacterial strain (Figs. 281 and 282).

The femoral metaphysis may only show a small area of hyperaemia or the synovial membrane the same. Later erosion of the cartilage may be present

from extension of either the original bone focus or an original synovial disease; in severe cases, we have an appearance which looks as though it had been gnawed by rats or mice, where the disease has been extensive; a small part of the epiphysis may be affected; in still more severe cases, the epiphysis may have undergone caseation, destruction or be separated and lie loose in the joint, in the latter the sequestrum is cut off by granulation tissue. Such a condition is found in the "caries necrotica" where the tuberculosis has been rapidly wide-spread and liquefied around some portion of undestroyed bone. It is to be distinguished from "caries sicca" or dry caries in which finally we have total caseation and liquefaction and a "residual abscess" with a surrounding zone of dense fibrous and granulation tissue. Caseation may cause extensive destruction without tubercular pus formation as caseation, liquefaction and an equal absorption occur pari



FIG. 282.—Tuberculosis of head of femur. (*Krause.*)
a, Separation of cartilage in form of hood.

passu. In such the granulations are firmer, almost cartilaginous in consistency, tending to cicatrization (Figs. 295, 296 and 297).

Liquefaction and tuberculous suppuration occur in a large percentage of the cases, which run their course unchecked by treatment, and the abscesses find exit in some direction of least resistance. Profuse creamy suppuration usually indicates that a part of the synovial membrane is involved or that there are large abscesses near the joint, while fungous granulations in sinuses, for example, usually give a mucous or serous secretion (Fig. 291).

True dislocation rarely occurs, although we may have a progressively extending condition known as "travelling acetabulum," where the rim of the acetabulum, which has become involved in the tuberculous process, has been destroyed and a new pseudo-acetabulum is formed above and posterior to the old on the dorsum of the ilium. In rare instances, portions of the acetabulum may be separated as sequestra. Bone atrophy is evident not only in the length but in the circumference of the former (Fig. 298).

Phthisis pulmonalis, is rare in hip disease, although some of the other osseous structures may present tubercular trouble. There seems to be an antagonism, according to Treves, between so-called internal and external tuberculosis, thus we rarely see subjects with external cervical glands enlarged, having pulmonary tuberculosis as well. Occasionally a case presents itself with double hip disease or while a case is under treatment for caries of one hip, the other hip may become involved. The second hip shows, however, a much milder grade of the disease and recovers first while the first hip involved runs a milder and shorter course than in single hip disease. This is probably explained by the formation of antibodies, conferring partial immunity. (*Opsonins*) *Wright, Transactions Royal Society*. We may have a tuberculous knee on the other or the same side, and so on with the other joints.

The disease, under proper treatment, may intermit or recover at any stage. If but slight destruction to the joint has occurred, function may be little, if at all impaired when repair occurs. If ankylosis occurs from extensive destruction, the femur and acetabulum are united by connective tissue or osseous bands later. The tuberculous hip abscesses may ulcerate into a blood or lymph vessel and infect the general system with general miliary tuberculosis, but more commonly the extension of the disease manifests itself as a meningitis. Tubercular meningitis as a metastasis is a complication much more frequently seen with a fatal termination in hip disease, than in any of the other tubercular bone lesions.

Symptoms.

The symptoms of coxalgia with arthritic involvement from neglect are unfortunately often so evident, that only the unwary can fail to appreciate the real nature of the trouble. Early diagnosis, however, as can readily be understood, is of prime importance, while the disease is still osteal and before it becomes articular. It is in the earliest stages, nevertheless, that the condition is commonly mistaken for knee joint disease or synovitis of the knee from the referred pain to that region, but most frequently for rheumatism, neuritis or myalgia.

There is an arbitrary subdivision of the symptoms of hip disease, into three stages, each of which has characteristic symptoms peculiar to itself and corresponding to the pathological changes occurring in the components of the joint, but it is to be borne in mind that these stages run into one another, so that a hard and fast line cannot be drawn. These stages are as follows: First, the stage of flexion, while the disease is primarily osteal; second, the stage of flexion, abduction and apparent lengthening, when the tubercular process has invaded the articulation; and third, the stage of flexion, adduction and apparent shortening when the pus finds an exit into the surrounding soft parts by a route of least resistance and repair is taking place by fibrous or bony ankylosis in a vicious position. It is to be understood that the disease may be arrested before the second or third stages are reached.

The First Stage.—(1) Often with the history of some fall or trauma, the onset of the disease begins very insidiously and gradually, and this should be noted in contrast to acute joint diseases, which come on suddenly.

2. The child favors the diseased leg and stands on the well one as much as possible.

3. Lameness is usually the first symptom noticed, being at first only the slightest limp which is characterized by a slight swaying of the body toward the affected side and which gradually becomes worse and is aggravated by the excessive use of the limb on the day previous and is more marked in the morning,

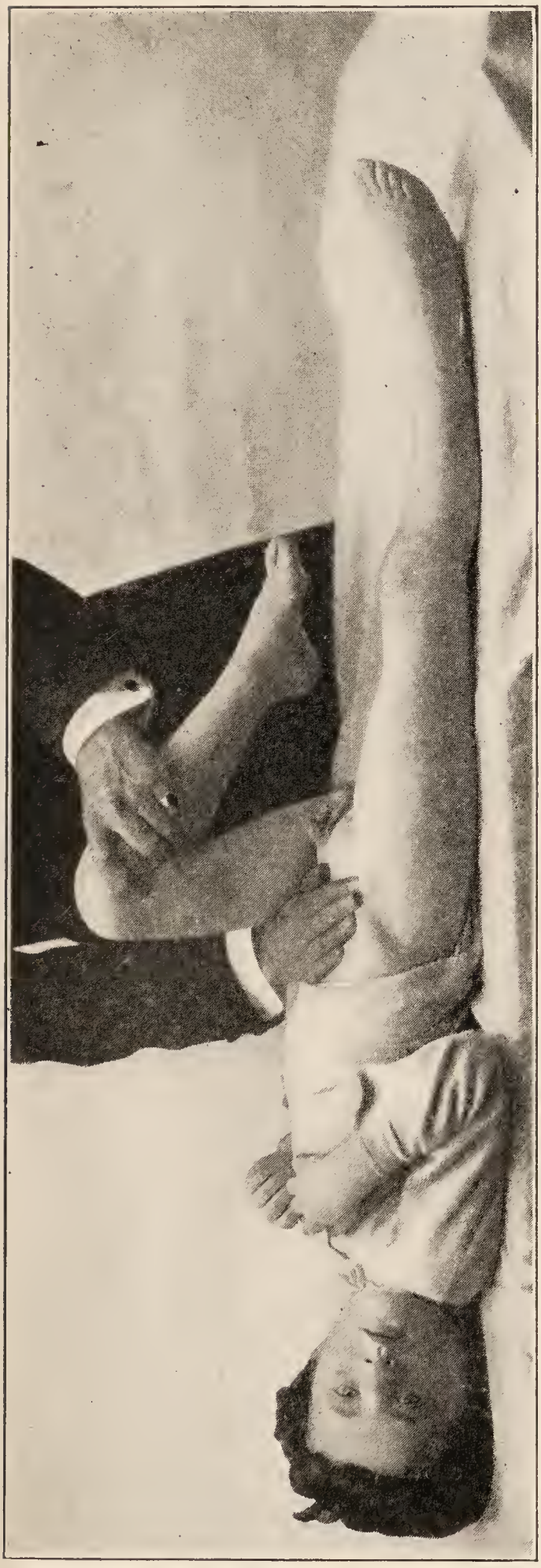


FIG. 283.—Test for limitation of flexion in hip disease. (*Young.*)

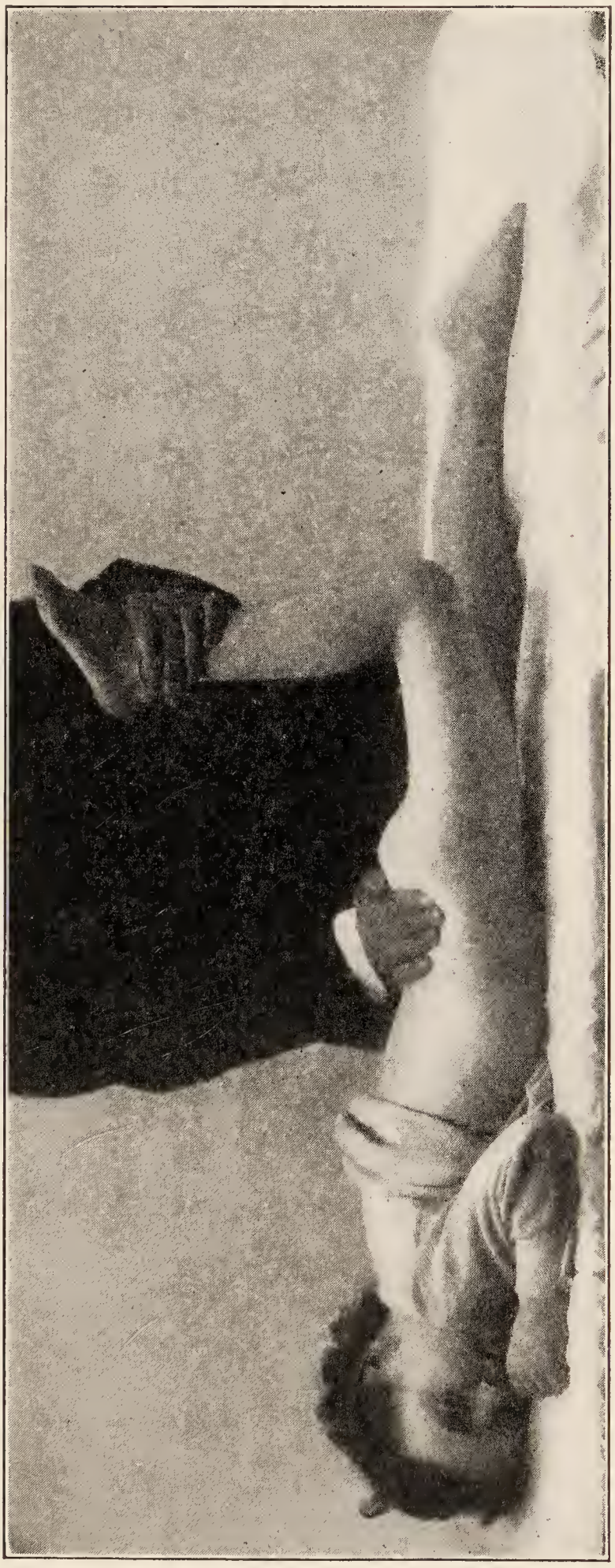


FIG. 284.—Examination for limitation of extension in hip disease. (*Young.*)

perhaps passing off during the day. The limp is due in part to pain and in part to stiffness about the joint, as its motions are limited more or less by *an involuntary reflex contraction of the muscles surrounding the joint*, which is Nature's method of protecting the disabled member from further jar or injury. This is

spoken of by Shaffer as the "neuro-muscular protection" of the joint or "muscular spasm." Often when no tetanic spasm can be felt in the muscles of the joint, if it is moved through its different arcs of motion, some of the muscles will be seen to give a spasmodic contraction or "strut," but usually a slight muscular rigidity can be detected near the normal limit of motion in even the earliest stages (Figs. 283 and 284).

4. Pain is subacute and a symptom more often produced by motion or muscle spasm, but is noticed at first following a period of activity and disappears with rest. It is usually referred to the antero-internal aspect of the knee, and like vertebral osteitis, is rarely at the seat of the disease; hence the mistakes frequently made in early diagnosis. This pain has been explained in various ways: (1) due to the stretching of the internal lateral ligament of the knee joint, from the abducted position of the leg; (2) from the fatigue of the muscular spasm, and (3) from what is the most generally accepted explanation, irritation of the obturator, sciatic or anterior crural nerves, whose branches of distribution are common to both the knee and hip joints and the sensation is referred to the most peripheral ends over a less extensive area on the anterior and internal aspect of the knee joint than is present in "tumor albus" or, as it is more commonly now known, tuberculous disease of the knee.

5. Induration, swelling and tenderness over the trochanter major and the joint capsule may be present even at this early stage. It is more marked later and can be detected by comparing on palpation the diseased and well joint at the same time. Later in the disease, there may be a definite bone hypertrophy over the trochanter major, probably from the epiphyseal stimulation of disease in the neck of the bone.

6. Limitation of motion, which was referred to under lameness is a constant early and reliable symptom, which is always present in true hip disease, and this muscular rigidity of a tetanic character tends in the earliest stage to hold the leg flexed and slightly abducted. This contraction of the psoas pulls the lumbar spine forward when the leg is on the examining table. If there is not complete limitation of motion in all directions, it is apparent at the limits of motion in several directions. Thus, if one leg is moved say in flexion beyond 60°, the muscles will strut and the pelvis will move, which is not the case on the sound side. There may be some muscular irritability of the lower erector spinae muscles *of the same side* and should not throw one off guard to suspect Pott's Disease. This limitation of motion is purely reflex at this stage as it disappears entirely under anaesthesia.

7. Muscular atrophy, which is an early and constant symptom is shown, first, by the wasting of the thigh and buttock of the diseased side, almost as soon as muscular spasm appears. Later the calf muscles on the diseased side show atrophy. Some authorities formerly considered that the trophic centres were involved, while others thought the atrophy due to peripheral irritation of the nerves independent of the trophic centres. Disuse and constant muscular spasm and inhibitive action to growth from the toxins of tubercular disease may now be considered as the chief causative factors. This best explains the atrophy both in length and circumference of all the bones of the leg and foot and the calf in the later stages of this disease as well as the muscular change. This atrophy

can easily be determined by comparative measurements of the thighs and calves at some points equi-distant from the anterior superior spines of the ilia on the sound and diseased limb. By measuring the lengths from the anterior superior spines of the ilia to the internal malleoli of the tibiae on each side, we

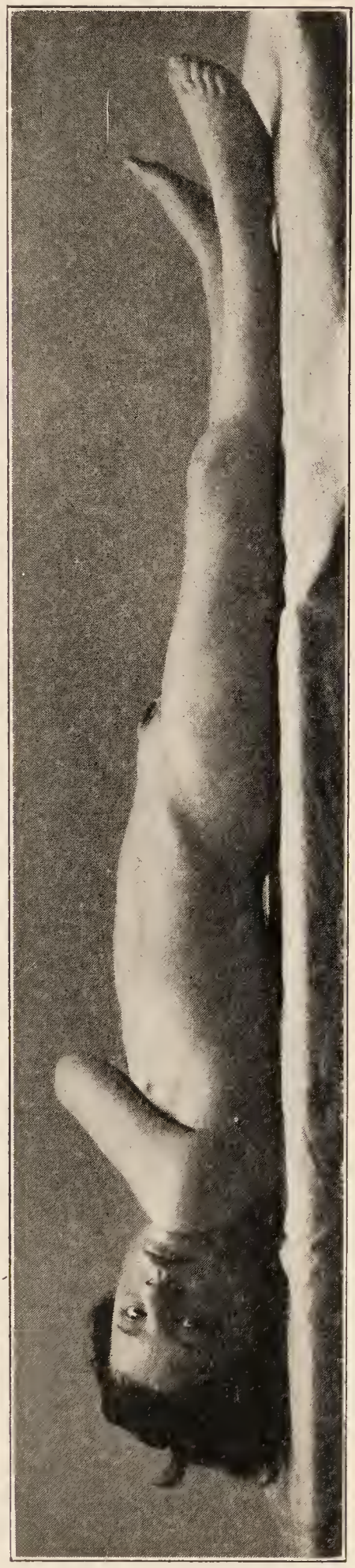


FIG. 285.—Early stage of hip disease, showing lordosis. (*Young.*)

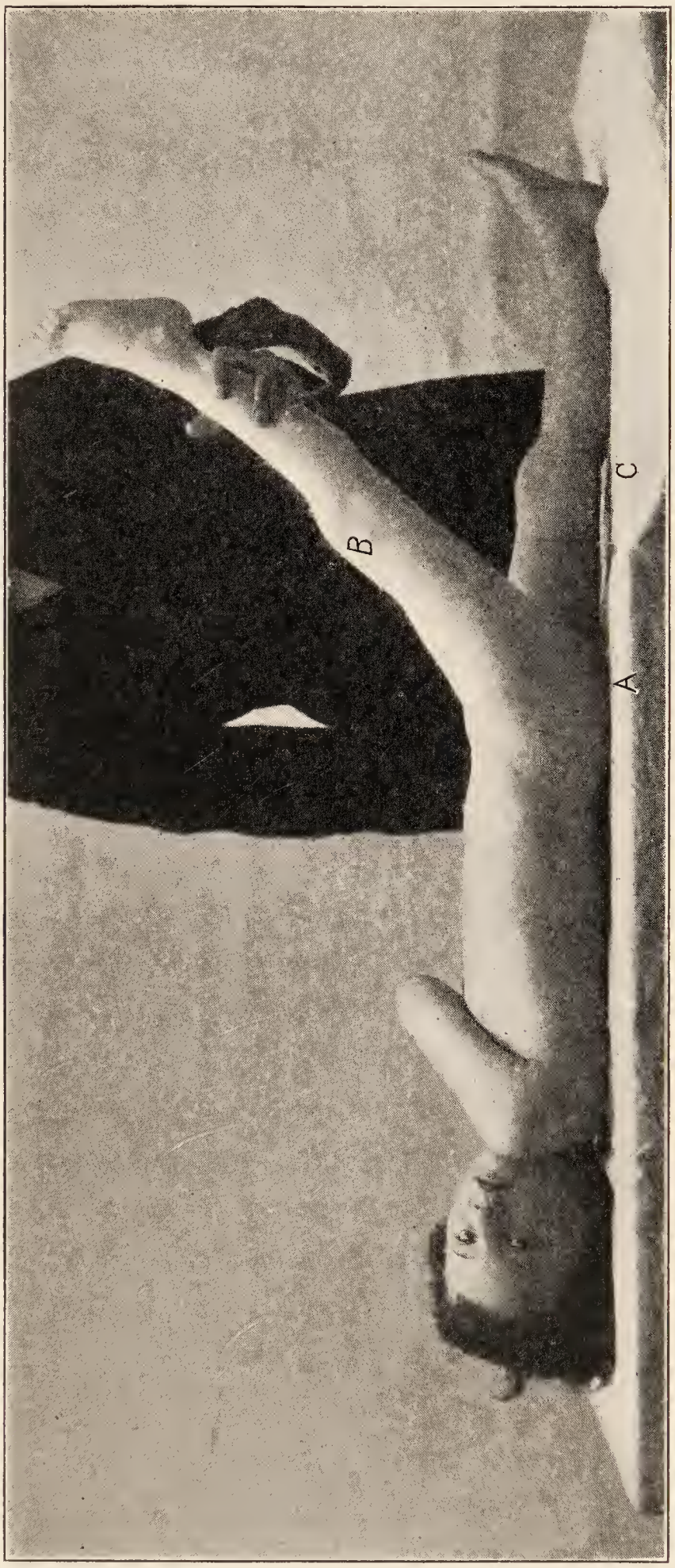


FIG. 286.—Same, showing disappearance of lordosis on flexion of thigh. BAC = angle of "position of flexion." (*Young.*)

can determine the shortening in the length of the bones. By the X-ray, we can, in more advanced cases, detect circumferential bone atrophy. The muscular atrophy is unlike the atrophy of paralysis in that the muscles are not flabby from degeneration of muscle fibers, but unduly rigid and firm.

8. In hip disease, even at an early stage, the inguinal and even the intra-pelvic glands above Poupart's ligament are found enlarged in some cases on the diseased side, as can readily be determined by comparative bilateral palpation. Some consider the latter induration referred to, an indication of acetabular disease. Deep palpation of the intra-pelvic glands may elicit tenderness.

9. The general condition of the patient may show no symptoms at first, but as the disease advances, we may have anorexia, enfeebled digestion and malnutrition, restlessness, peevishness, and an elevated temperature of from 99 to 101°F., rarely higher. None of these last named symptoms are as a rule present early in the first stage and the child may seem unusually plump from the normally large amount of adipose tissue seen in childhood, giving an idea of health, which really is present, with the exception of the localized tuberculous trouble.

The Second Stage.—This stage shows a marked exacerbation in all of the symptoms of the first stage with the addition of abduction and night-cries, as the articular surfaces are now involved.

1. Lameness is decided, the pelvis is tilted *down* on the diseased side, so that the weight is borne as much as possible on the sound limb and the lame leg is flexed, abducted and favored (Fig. 289).

2. Pain is persistent and agonizing and increased by the slightest jarring or motion or relaxation of the muscular tension thus forcing the bones of the joint together.

Some consider pain in the knee "femoral coxalgia," pain in the joint "arthritic coxalgia" and pain in the iliac fossa, "acetabular coxalgia," but pain in the knee of the inner side of the lower part of the thigh, is the commonest location. In some cases of hip disease, pain is very slight, or even absent and other symptoms must be relied upon to establish the true nature of the trouble.

3. Limitation of motion is still more marked in the second than in the first stage and the limb is flexed and abducted. After prolonged joint disease, the muscles, ligaments, capsule and bones may be so adaptively altered and contracted that the abnormal position of the limb will not disappear under anaesthesia, as is seen in the simple reflex muscular contraction of the neuro-muscular protection of the joint in the first stage.

4. Muscular atrophy becomes more marked in the diseased leg in this stage and may be present in the calf muscles as well as in the thighs and buttocks. Flattening of the buttock on the diseased side is apparent from this atrophy, as well as from flexion and abduction, as seen in a normal individual, when the fold of the nates is obliterated. This, however, in part is due to the peri-articular swelling, filling in the post-trochanteric fossa.

5. "Night-cries" may occur at any stage, but are more common in the second. They usually occur early in the night just as the child is losing consciousness, from relaxation of the muscular rigidity, and may disappear immediately or continue to recur when sleep is again attempted. They indicate acute disease or extension of the pathological process. They are painful and unlike "night-mare" are not accompanied by a dream. The pain is sudden and severe and leaves the hip aching or with a bruised sensation.

6. "Secondary abscess" formation is common in the second stage, but may be the first symptom noticed by the parents. If a case is efficiently treated, "secondary abscesses" may never form, but it is almost invariable in untreated cases, usually appearing during the first year of the disease. Under efficient treatment, a primary abscess may disappear and never come beyond the surface of the bone, but be absorbed.

It should be borne in mind that these are "cold abscesses" and the contents are sterile, so far as pyogenic bacteria are concerned, consisting of broken-down bone tissue, serum, etc. They burrow along the fasciae as a rule in the direction of least resistance when they become "secondary" and may find exit at some point distant from the original foci of disease. They may thus be classified as primary (in the bone) and secondary (outside the bone), intra-articular and extra-articular, or as femoral, articular and acetabular, the last being the most

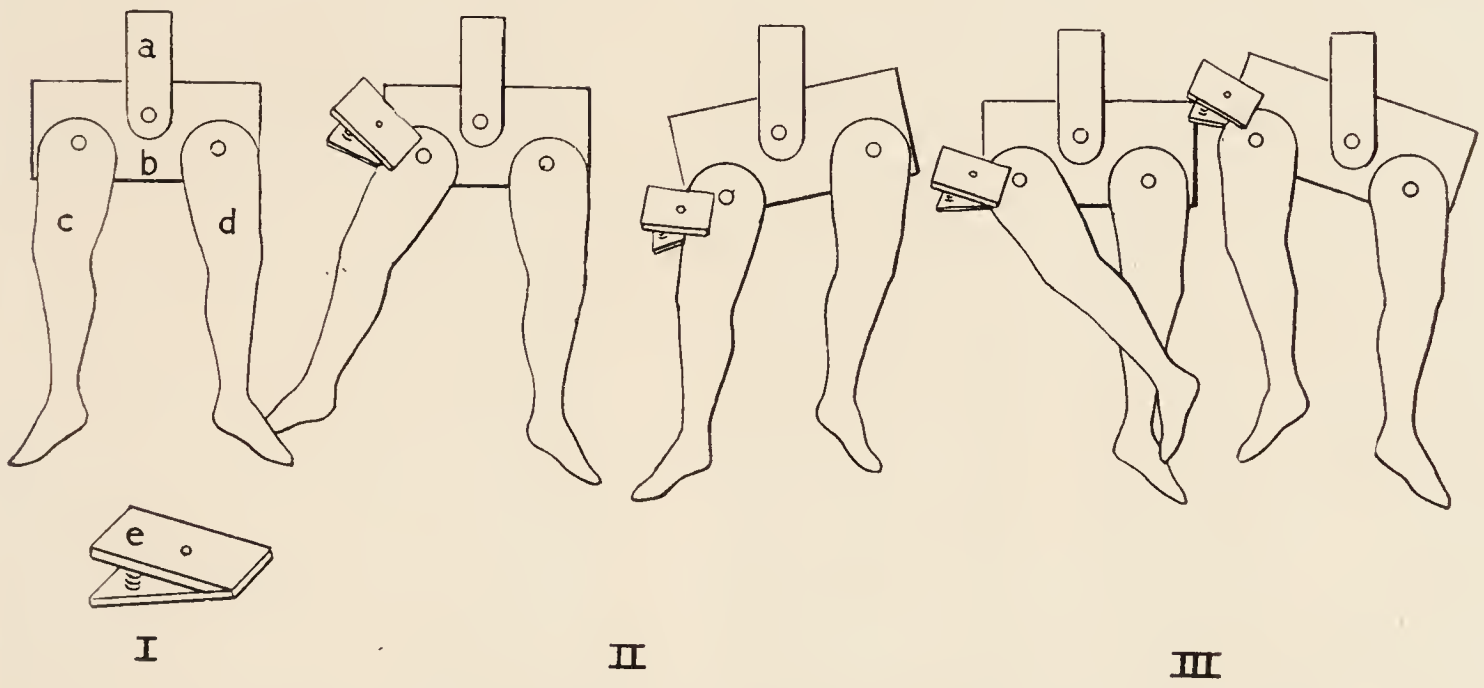


FIG. 287.—Diagram illustrating fixation in abduction and adduction.

I.—A, spine; B, pelvis; C and D, legs; E, spring clip, indicating muscle spasm and fixation. Pelvis is level and legs equal and parallel.

II.—Right leg fixed by muscle spasm or ankylosis in abduction. When parallelism is restored, the right leg is apparently the longer, as the pelvis is tilted downward.

III—Right leg fixed by muscle spasm or ankylosis in adduction. When parallelism is restored, the right leg is apparently the shorter, as the pelvis is tilted upward.

serious, as they may burst into the peritoneum and are difficult to treat. The advent of secondary abscess is usually without constitutionl symptoms, but if extensive, there will likely be pain, slight elevation of the evening temperature, slight rigor, sweating and anaemia (suppurative leucocythaemia). If the evening temperature is persistently high, i.e., over 102.5., *secondary infection* with pyogenic cocci or bacteria has occurred in the abscess and the condition becomes hectic.

7. The general rule may be stated that the temperature in all tubercular bone affections, when of any extent, is slightly elevated (from 99 to 101°F.). This is of great value in diagnosis between an acute and chronic joint affection, but even in the latter, the temperature may be high in secondarily infected abscesses, when leucocytosis is present also.

8. Joint crepitation or grating is a sign of erosion of the cartilage and exposure of cancellous bone. It may rarely be obtained by friction, which should never be resorted to, as it is unnecessary for diagnostic purposes, painful and

very likely to increase the damage already done by disease. Extensive granulation in the joint usually obscures this sign.

9. The general condition of the patient, especially during the acute periods of the second stage, suffers more than in the first and the child becomes pallid, weak and thin, especially after secondarily infected sinuses from the tuberculous bone abscesses have discharged for some months, with the coincident anorexia, insomnia, pain and poor assimilation (Fig. 287).

The Third Stage.—In this stage, we may have limitation of motion in all directions, subsidence of night-cries, which may suddenly cease from proper protection, healing or subluxation (travelling acetabulum). True dislocation occurs very rarely indeed. As a rule, the leg is held flexed and *adducted*, possibly due to muscular spasm and capsular and cicatricial contraction with elevation and backward and upward thrusting of the pelvis to gain parallelism of the legs with *apparent shortening*. In the third stage there may be real shortening from bone atrophy, epiphyseal inhibition and destruction, as well as the greater apparent shortening from elevation of the pelvis on the affected side (Fig. 288).

Recovery may occur at any stage and the sooner treatment is instituted, the better the ultimate result will be. In cases where there has been no suppuration, the chances for the perfect restoration of the normal motions are best

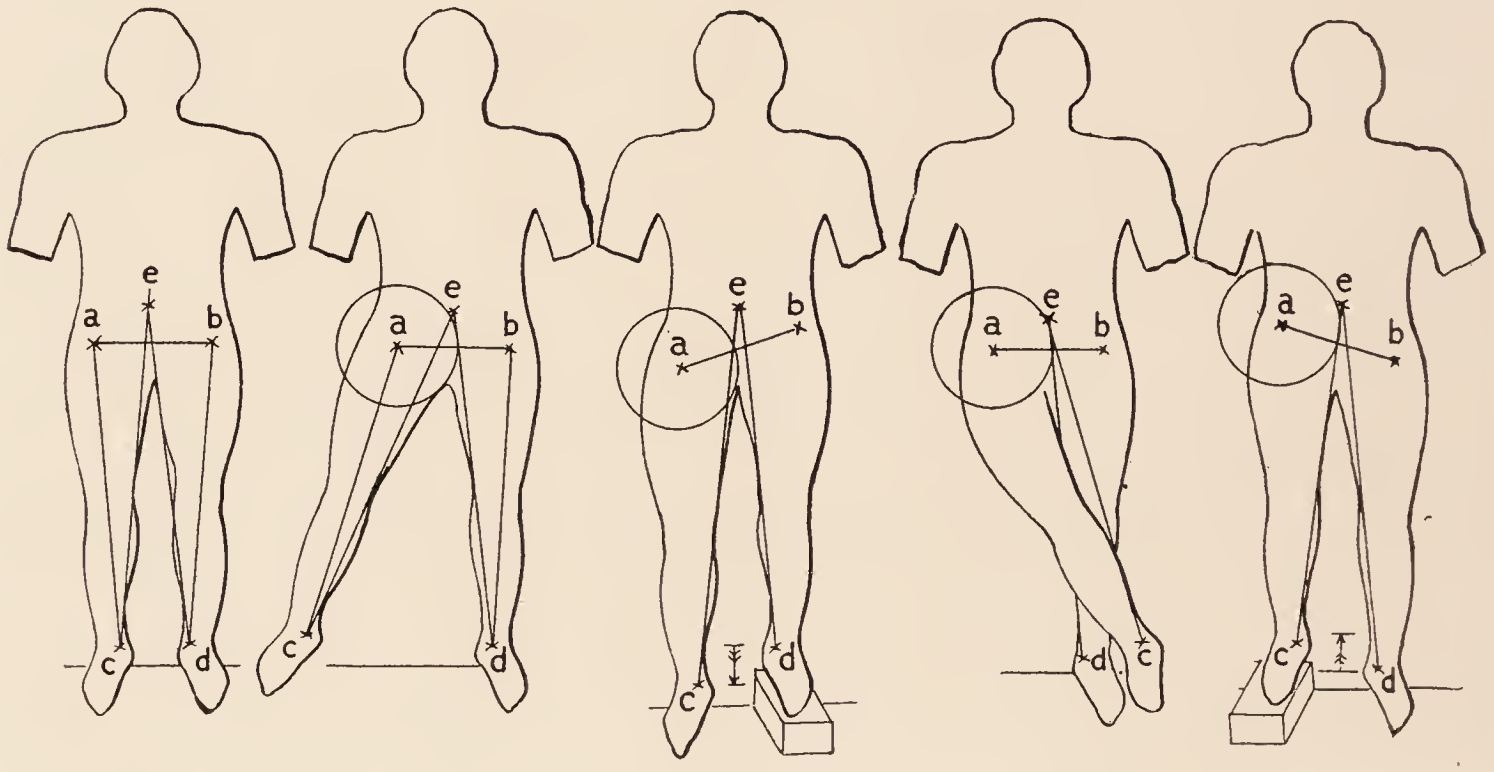


FIG. 288.—Diagram indicating apparent lengthening and apparent shortening by muscle spasm or ankylosis.

I.—The legs are parallel and the pelvis horizontal. ac = bd, ec = ed.
II.—The circle indicates fixation. Right leg abducted and pelvis horizontal ec > ed.
III.—Parallelism of legs restored in II; pelvis therefore tilted down and apparent lengthening of right leg evident as ec > ed.
IV.—Right leg fixed, adducted and pelvis horizontal. ec < ed.
V.—Parallelism of legs restored in IV; pelvis therefore tilted up and apparent shortening is evident, as ec < ed.

Death may occur from amyloid disease of the viscera, due to prolonged pyogenic infection plus the tubercular suppuration; tuberculosis of some distant organ, particularly meningitis or from some intercurrent disease, which the child's lowered vitality cannot combat.

Diagnosis.

1. **Limitation of Motion.**—This is due to reflex muscular spasm and is the diagnostic sign of the greatest value, is characteristic, but not pathognomonic,

being one of the earliest and most constant symptoms. It is determined as follows: With the thumb and middle finger of the left hand upon the anterior superior spines of the ilium, and the right hand grasping the patient's ankle, the slightest *movement of the pelvis with the leg* can readily be detected. The sound limb is examined first in the following motions at the hip joint, viz.

Flexion, with the leg fully extended on the thigh, and its motion is found to be normally from 90 to 135°, depending on the age of patient.

Abduction, with the leg fully extended on the thigh, is found to be normally from 30 to 90°.

Adduction, with the leg fully extended on the thigh, is found to be normally from 30 to 60°.



FIG. 289.—Early stage of hip disease in left leg. Weight borne on right.

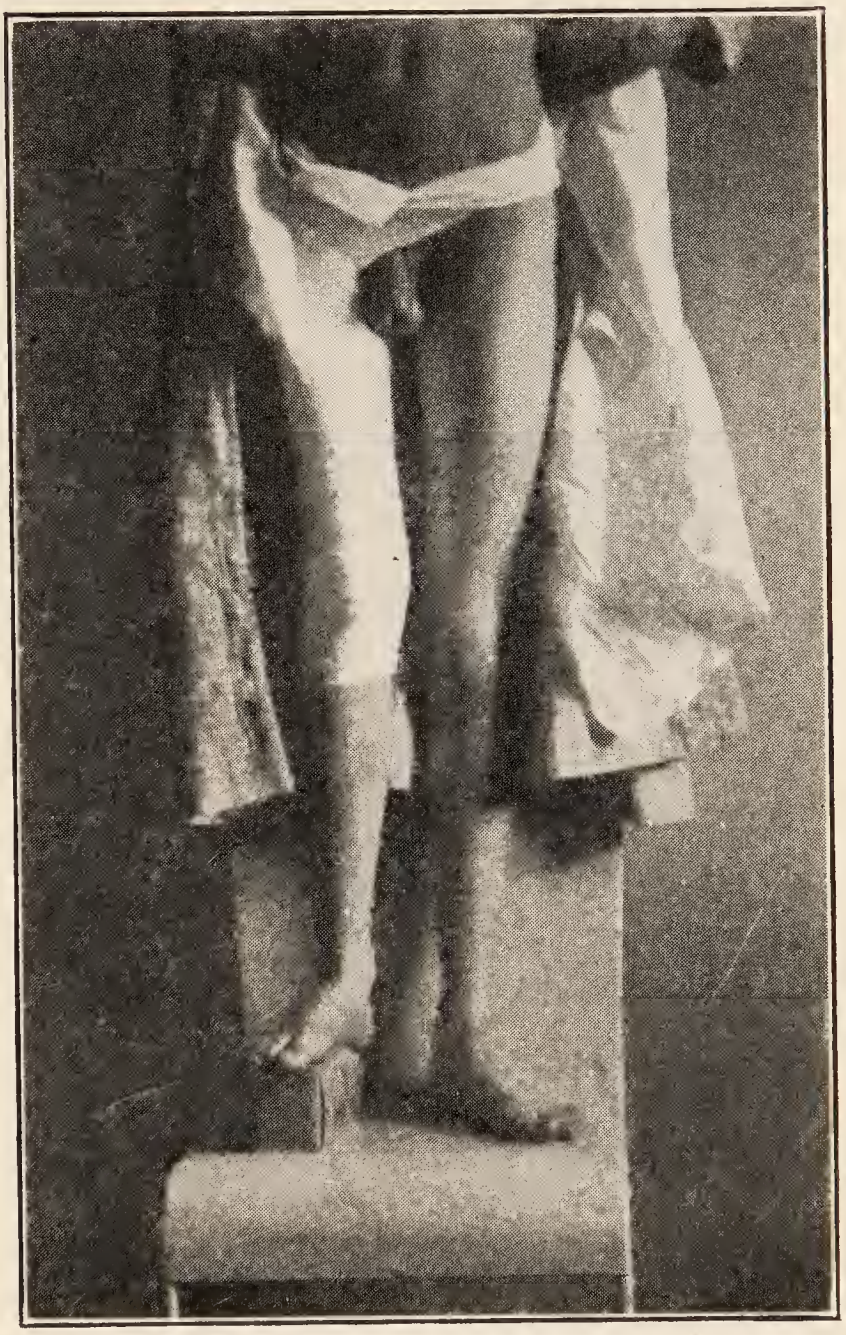


FIG. 290.—Adduction, flexion and shortening in third stage.

Rotation, with the thigh flexed at a right angle with the body and leg with the thigh a like amount, is found to be normally about 90° outward and slightly less inward.

Extension, with the child rolled on its face and leg flexed to 90° with the thigh, 10° (Fig. 284). (See test for Psoas Contraction in Pott's Disease, Fig. 124.)

Then the lame leg is moved similarly through the various motions and the limitations as compared with the normal and noted in degrees.

2. **Atrophy.**—This is determined as follows: two points are measured equidistant on each thigh from the anterior superior spines of the ilia and compara-

tive circumferential measurements of the two thighs made at these points. Similarly in advanced disease the calves are measured. (See Chapter XII.) Abscess burrowing between the muscles in severe disease manifests itself by increased circumferential measurement on the lame side.

3. **Length of Legs.**—The true length of the legs is determined by measuring from the anterior superior spine on each side to the internal malleolus. Even early in the disease, slight shortening of the diseased leg is often noted. This is known as "real shortening."

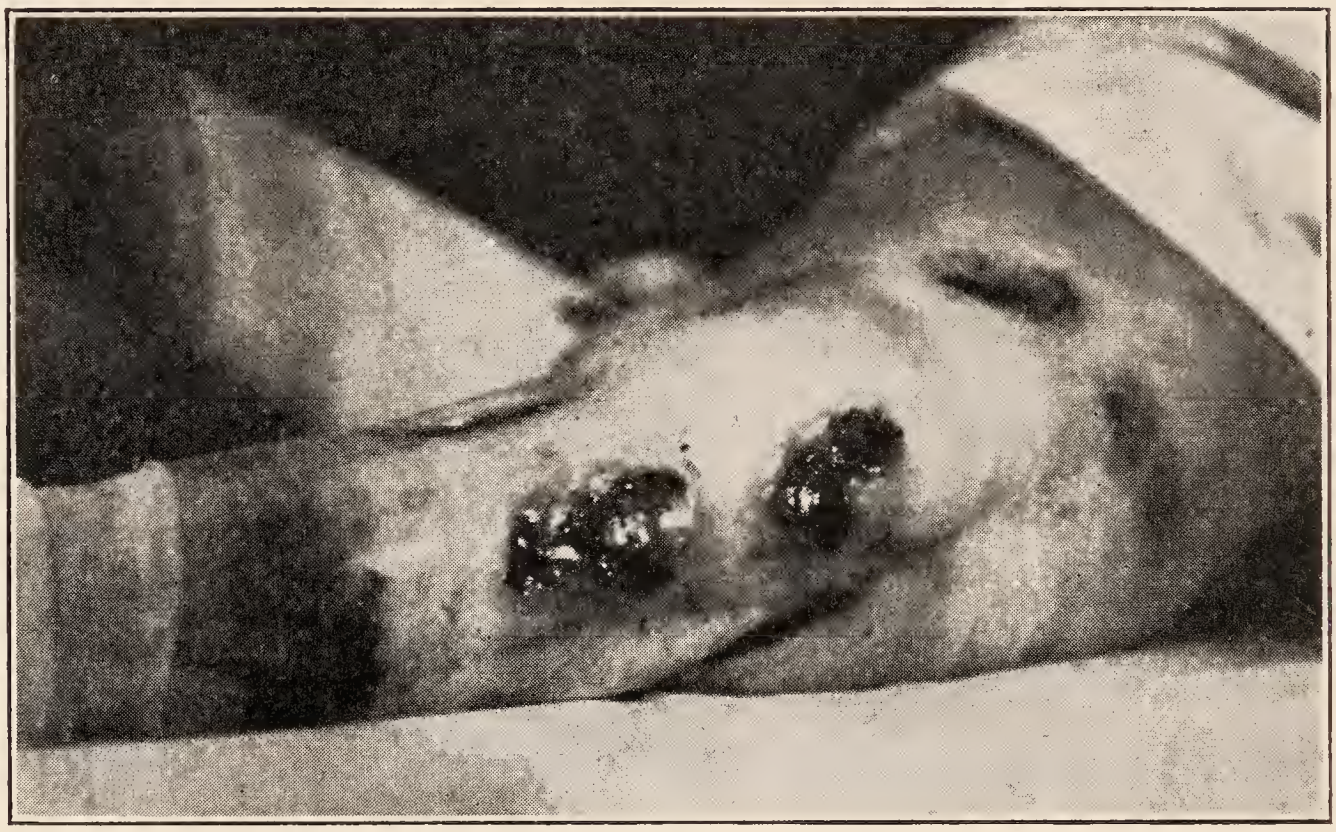


FIG. 291.—Severe case showing sinuses.

If the pelvis is tilted down on one side, and so held by muscular rigidity, that leg will seem longer and vice versa if the pelvis is tilted up on one side, the leg will seem shorter. This is known as "apparent lengthening or shortening," as the case may be, and is determined by measuring from some medial point, (usually the umbilicus), above the pelvis to the internal malleolus of each leg (Figs. 287 and 288).

A normal position of adduction is present in all individuals due to the greater separation of the thighs at the pelvis than at the knees. This is especially noticeable in females.

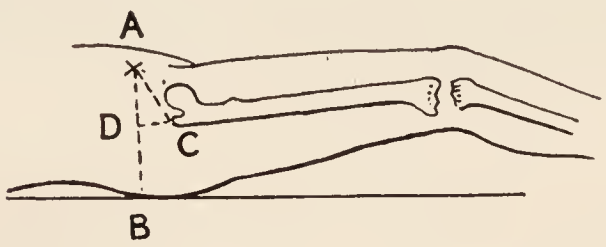


FIG. 292.—Bryant triangle—ACD.



FIG. 293.—Roser Nelaton line.

Bryant's Triangle.—A method to determine whether capital dislocation or shortening or bending in the femoral neck is present is obtained as follows: with the patient lying on the back on an examining table, a verical line is drawn from each anterior superior spine to the table which we will call *AB*. Then a line is drawn to the tip of the trochanter from the anterior superior spine on each side which we will call *AC*. From *C* a perpendicular line is drawn to the first

line at a point *D*. The length of *CD* will give us the amount of upward displacement as compared with the normal hip and the distance *AD* will give us the degree of forward or backward twist in the femoral neck. The triangle *ACD* thus formed is known as Bryant's Triangle. It is needless to say in plotting out this triangle the toes and patellae are to be pointing directly upward, that is, with the thighs neither rotated inward nor outward (Fig. 292).

Roser-Nelaton Line.—Another method to determine whether a shortening due to subluxation or other cause is present, we draw the "Roser-Nelaton" line between the anterior superior spine and the tuberosity of the ischium and if the trochanter major, which should normally be on this line, is above it, there is subluxation of the femoral head or bending downward or fracture of the femoral neck (Fig. 293).

Lovett's Rule.—Lovett in order to determine in degrees the amount of abduction or adduction, found the amount of real and apparent shortening and the distance between the anterior superior spines and stated "if the practical or apparent shortening is greater than the real shortening, the leg is held in adduction." He constructed a table, based on trigonometric calculation of the angles of the triangles formed by the intersection of the lines from the umbilicus and anterior superior spines to the internal malleoli and the line between the anterior superior spines, which gives us a reading in degrees (Fig. 288).

LOVETT'S TABLE SHOWING DEGREES OF ABDUCTION OR ADDUCTION*

DISTANCE BETWEEN ANTERIOR SUPERIOR SPINE IN INCHES

Difference in inches between real and apparent shortening.	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	11	12	13
¼	5	4	4	3	3	2	2	2	2	2	2	2	2	1	1	1	1	1
½	10	8	7	6	5	5	4	4	4	4	4	4	4	3	3	3	3	2
¾	14	12	11	10	8	8	7	7	6	5	5	5	5	4	4	4	3	3
1	19	17	14	13	11	10	9	9	8	7	7	7	6	6	6	5	5	4
1¼	25	21	18	16	14	13	12	11	10	9	9	8	8	7	7	7	6	6
1½	30	25	22	19	17	15	14	13	12	12	11	10	10	9	9	8	7	7
1¾	36	30	26	23	20	18	17	15	14	13	13	12	11	10	10	9	8	8
2	42	35	30	26	23	21	19	18	16	15	14	14	13	12	12	10	10	9
2¼	..	40	34	30	26	24	21	20	19	17	16	15	14	14	13	12	11	10
2½	..	..	39	34	29	27	24	22	21	19	18	17	16	15	14	13	12	11
2¾	..	..	..	38	32	29	27	25	23	21	20	19	18	17	16	14	13	12
3	..	..	..	42	35	32	29	27	25	23	22	21	19	18	18	16	14	13
3¼	..	..	..	.	39	36	32	30	27	26	25	22	21	20	19	17	15	14
3½	..	..	..	..	..	40	35	33	30	28	26	24	23	22	21	19	17	16
3¾	..	..	..	..	..	..	38	35	32	30	28	26	25	23	22	20	18	17
4	..	..	..	..	..	..	42	38	35	32	30	28	26	25	23	21	19	18

* Lovett, Boston Med. and Surg. Jour., Mar. 8, 1888.

Example.—Let us suppose the distance from the
Right anterior superior spine to internal malleolus = 26 inches
Left anterior superior spine to internal malleolus = 25½ inches } real shortening is ½ inch.
Right internal malleolus to umbilicus = 28 inches
Left internal malleolus to umbilicus = 26 inches } Apparent shortening is 2 inches.
Between the anterior superior spines of the ilia = 8 inches.

The apparent is greater than the real shortening, therefore the position of the left leg is that of adduction.

Now, 2 minus ½ = 1½, and the distance between the anterior superior spines = 8 inches, then by following the line in Lovett's Table where 1½ inches intersects the line for pelvic measurement of 8 inches, 11° is found to be the angle of deformity and as the apparent shortening is greater than the real shortening, the leg is adducted 11°.

We must distinguish carefully between "position of adduction or abduction" and "motion in adduction or abduction," and between "position of flexion" caused by muscular contraction or ankylosis and "motion in flexion."



FIG. 294.—Marked atrophy and deformity in advanced hip-joint disease. Scars of old sinuses. (*Young.*)

Kingsley has devised a means and a table to compute mathematically the "position of flexion" in a thigh.[1]

With the patient on the back, so that the lumbar spines touch the examining table, measure from the hip joint along the femur for two feet or 24 inches, an imaginary line *AB*. Let fall a perpendicular from *B* to the examining table at a point we call *C*. Then the distance in inches from *C* to *B* is found and Kingsley's Table is referred to.

If *C* coincides with *A*, it is easy to see the leg is flexed 90°. If *B*, coincides with *C*, the leg is not flexed at all, i.e. flexion is zero degrees. If *CA* is 17 inches and *BC* is 17 inches then the flexion is 45° approximately, as "the square of the hypothenuse equals the sum of the squares of the other two sides" as 17 × 17 + 17 × 17 equals approximately 24 × 24. From these facts, it is easy to see how the table was constructed (Fig. 286).

KINGSLEY'S TABLE

Inches	Degrees	Inches	Degrees	Inches	Degrees	Inches	Degrees
0.5	1	6.5	16	12.5	31	18.5	50
1.0	2	7.0	17	13.0	33	19.0	52
1.5	3	7.5	19	13.5	34	19.5	54
2.0	4	8.0	20	14.0	36	20.0	56
2.5	6	8.5	21	14.5	37	20.5	58
3.0	7	9.0	22	15.0	39	21.0	60
3.5	9	9.5	24	15.5	40	21.5	63
4.0	10	10.0	25	16.0	42	22.0	67
4.5	11	10.5	27	16.5	43	22.5	70
5.0	12	11.0	28	17.0	45	23.0	75
5.5	14	11.5	29	17.5	47	23.5	80
6.0	15	12.0	30	18.0	48	24.0	90

[1] Kingsley, Boston Med. and Surg. Jour., July 5, 1888.



FIG. 295.—First stage of hip disease.

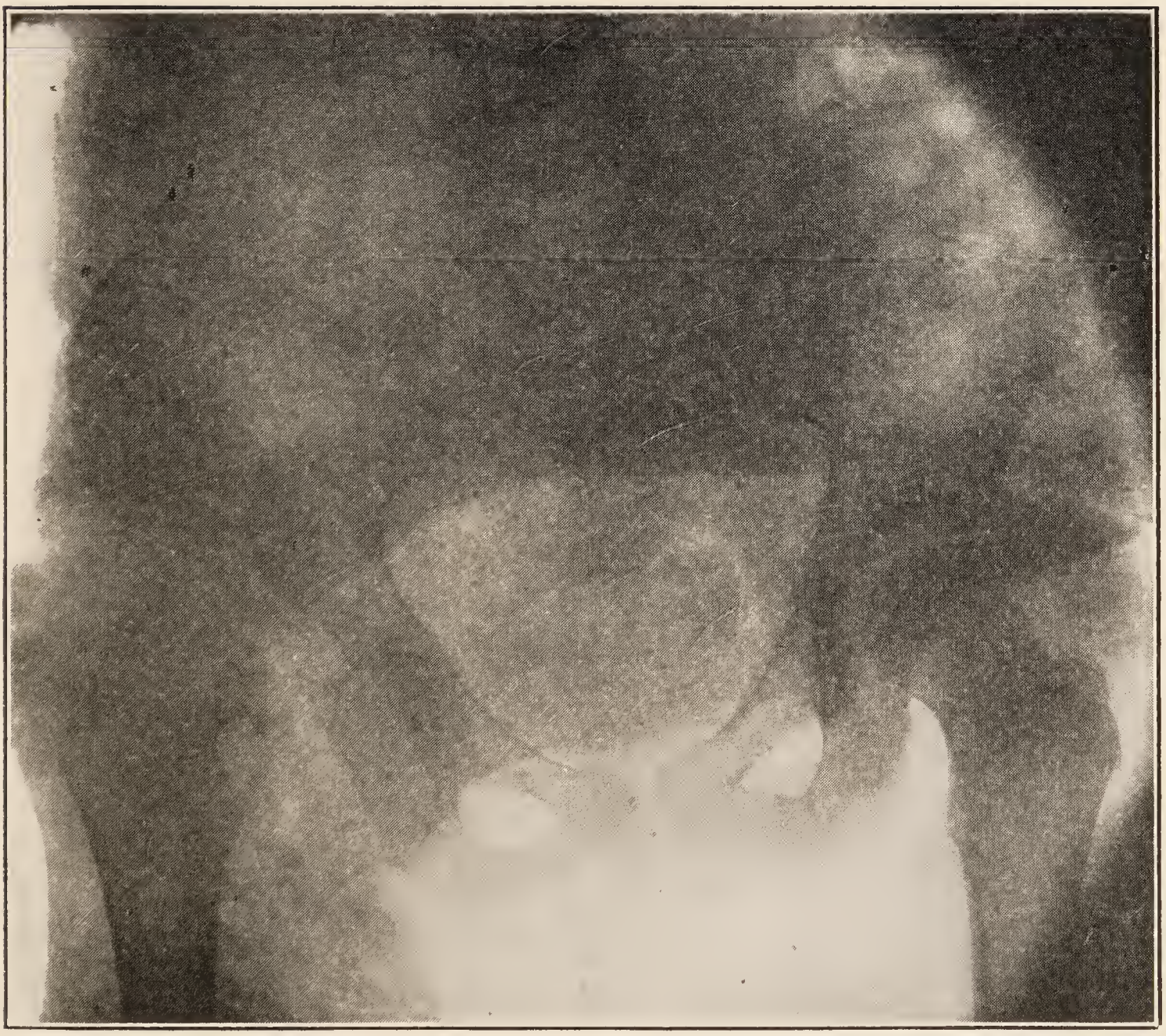


FIG. 296.—Second stage of hip disease.

Pain, temperature, night-cries, abscess and swelling of the capsule and trochanter have been spoken of at length under symptoms and need no further comment here, but they should be carefully considered in making a diagnosis. To elicit pain, the common habit among surgeons and physicians of striking the heel and forcing the bones of the joint together is cruel, unscientific and unjustifiable for diagnostic purposes.

The Radiograph and Tuberculin reaction often are great aids in the diagnosis, especially the former, which not only enables one to verify impressions



FIG. 297.—Third stage of hip disease.

created by symptoms as to the nature of the trouble, but to note from time to time the progress of the disease (Figs. 295, 296, 297 and 298).

The X-ray shows us, even from the onset of the disease, that a pathological change is taking place in one of the favorite seats of bone tuberculosis. As to the comparative value of the skiagraph and tuberculin in diagnosis, it seems to the author, it is all in favor of the skiagraph, as a certainty, if we can believe our eyes against very uncertain data obtained by a positive subcutaneous tuberculin test alone, which does not tell us in what part of the body the tuberculosis is; whether it is lung, gland, or joint.

Some authorities claim that an elevation of 2° in the temperature sufficient to constitute a reaction from tuberculin, but that the patient must show two of the following symptoms, viz., chilliness, headache, nausea or muscular pains. The subcutaneous test as pointed out in the Chapter on Pott's Disease may produce a negative phase" or lower the patient's power of resistance and has given way in our own and many other clinics to the Von Pirquet or Intra-dermal "focal reaction."

A "focal reaction" consists of an area of hyperaemia at the point of injection of the tuberculin and is not seen in the non-tuberculous. It appears in from 18 to 48 hours after injection or scarification.



FIG. 298.—Primary acetabular disease. "Travelling Acetabulum."

A "local reaction" is sometimes seen following the subcutaneous test and consists of more active pain and muscular spasms, with increased limitation of joint motion, but this is by no means a constant and reliable test, for other conditions and influences may cause the same thing.

The opthalmic or conjunctival Tuberculin test is no longer given as it is too dangerous; it is likely to lead to corneal ulcers and scars. (Calmette's Test.)

With good X-ray negatives, in conjunction with the symptoms and history, mistakes in the diagnosis of Tubercular Hip Disease for Rheumatism, Coxa Vara, Congenital Hip Dislocation, Infantile Paralysis, Osteo-Arthritis, Arthritis Deformans, Perthe's Disease, etc., are now practically impossible. Only in the very earliest stages where the skiagraph has failed to show any joint lesion should one be tempted to use tuberculin subcutaneously.

The negatives show, first, at the earliest stage, usually *a slight clouding of the joint* and at the epiphyseal or metaphyseal line of the head of the femur, a region lighter than the surrounding uniform dark bone; a little later, this will show a heterogeneous mixture of light and dark areas in the epiphysis of the femoral head, suggesting a disorganization or osteoporosis.

The next type we have, is that seen, when the disease has progressed a little further and a *marked clouding* of the whole joint occurs, which is most characteristic, as though we saw the joint structures through a haze, then gradually first the epiphysis of the Great Trochanter is lost to view and then that of the head is blurred out and the whole joint looks much whiter and indistinct in outline than its mate. At times as the disease advances we note punched out areas of the head or neck or acetabulum that have undergone caseation, liquifaction, absorption or still remain as so-called "tubercular pus" in the capsule. Still later we see efforts at repair with clearing of the bone shadow, *never new bone formation nor exostoses*, but condensation, consolidation and ankylosis. X-ray plates for diagnosis should always be made to include both joints for comparison of the well with the diseased on one plate at the same time. Later, if special detail is desired, a single plate with diaphragm used may be made of the affected hip.

The clouding seen in the early and acute stages gradually disappears as healing begins. This clouding is due possibly to the hyperaemia and phagocytes hurrying from the scene of the conflict taking up the lime salts in the diseased area and causing this appearance. If we can judge from the X-ray as to the amount of tissue involved, aside from its diagnostic value, the X-ray affords a most excellent method of studying the gross pathology second only to the post-mortem specimens and the progress in healing or the reverse.

Differential Diagnosis.

(*a*) Contusions and Sprains of the Hip, which have been mistaken for Hip Disease, soon disappear with rest in bed. These, however, it must be remembered are at times predisposing causes of Coxalgia.

(*b*) Often confused, especially in the early stages of the disease, is acute Rheumatism of which we often have an inherited or acquired history; also history of bad teeth or tonsils etc., of occupation or exposure to dampness as predisposing causes, pain preceding lameness, no general muscular rigidity around the joint, but local hyperaesthesia and hyperpyrexia (when the rheumatic attack is severe). In pure Articular Rheumatism usually several joints are involved and the onset is sudden. In Chronic Arthritis or Osteo-arthritis we have Exostoses (Fig. 299).

(*c*) Gall Stone or Nephritic Colic, Appendicitis, Rhachitis, Scurvy and Pseudo-Hypertrophy are entirely dissimilar and should never be mistaken for Hip Disease, if all the symptoms are compared. Still, such errors have been made, from abdominal muscle spasm causing flexion of the thigh on the body.

(*d*) Lumbar Pott's Disease may cause flexion of the hip by Psoas contraction, but never limitation of motion in all directions, which is an early symptom of true Hip trouble.

(*e*) Bursitis, acute Arthritis and acute Osteomyelitis show characteristic symptoms of an acute inflammation and are usually associated with redness,



FIG. 299.—Exostoses of femur. (*Philadelphia College of Physicians.*) (*Young.*)

swelling, heat and pain. The temperature is high, general disturbance marked, onset is sudden and the course is rapid, if septic or suppurative and leucocytosis is present; these symptoms are not present in Coxalgia. The X-ray will show in acute Osteomyelitis *no clouding*, but irregular outline, and later periosteal separation, new bone formation, involucra and sequestra (Fig. 300).

There is no atrophy, muscular spasm nor night cry, so characteristic of Tuberculous Arthritis nor clouding in the X-ray.

(*f*) In Coxa Vara, the Trochanter is above the Roser-Nelaton Line and we have bending of the Femoral neck with shortening of the leg and limp and no limitation of motion, as a rule, except in abduction and outward rotation. Pain, muscle spasm and night cries are not present. The X-ray shows at once the nature of the condition (Figs. 313, 317 and 320).



FIG. 300.—Acute osteomyelitis of the hip-point.

(*g*) Infantile Spinal Paralysis gives the reaction of degeneration in the muscles with the galvanic current, and lessened or no response to the faradic current. The gait is tottering, flaccid, not stiff, and there is no muscular spasm, but abnormal mobility, and the muscles are flabby and wasted.

(*h*) Congenital Dislocation of the Hip has no muscular spasm nor other symptoms of Tubercular Hip Disease, but excessive mobility and the limp is very different. The radiograph immediately shows that the femoral head is not in the acetabulum as do measurements at Nelaton's Line (Figs. 325 to 327).

(*i*) Tubercular Sacro-Iliac disease may have apparent elongation, but not shortening nor adduction and the pain may be increased by pressure over the Sacro-iliac Synchondrosis or on the alae of the Ilia. Radiating pain down the pelvis and in the distribution of the Sciatic Nerve is characteristic.

(*j*) Syphilitic periostitis and osteochondritis are not situated in the joint, but in the diaphysis as a rule. The whole bone is thicker and more dense than normal as seen in the X-ray. Charcot's Joint Disease in the hip is very rare.

(*k*) Neuromimetic or Hysterical Hip Disease may be diagnosticated by the absence of atrophy, shortening and disappearance of the muscular spasm under prolonged pressure or when the patient is diverted.

(*l*) Sacro-iliac Strain is recognized by the "Goldthwait sign" obtained on flexing the leg (extended at the knee) on the trunk when pain will radiate down the back of the leg. The X-rays rarely show a gaping of the Sacro-iliac Joint. This lesion is a tearing of ligaments only, as a rule and not an actual separation of the component bones, but a slight subluxation.

(*m*) Perthè's Disease shows a flattening of the epiphysis, probably traumatic, gradual in onset, little pain if any and slight limp (Fig. 322).



FIG. 301.—Cured case. Unusually good result. Full extension.

Prognosis.

Hip Disease runs its course to spontaneous ultimate healing, but is influenced by early treatment, virulence and extent of the infection, the age of the patient, the hygienic surroundings, social status and complications. Disease after puberty is more dangerous. The mortality is higher in dispensary patients, than in those seen in private practice, naturally, as the latter have better care and hygienic surroundings (Figs. 301 and 302).

Tubercular Disease elsewhere renders the prognosis more unfavorable.

Abscess with sinus formation renders perfect recovery with normal joint function doubtful, and is the rule in neglected or cases not treated until late in the disease.

The more efficient treatment is and the sooner treatment is begun, the greater the chances are for a perfect recovery and the less chance for sinus formation.

Mortality.

The Mortality is variously estimated at from 5 to 30 per cent. Relapses are common if treatment is discontinued too soon. A relapse tends to extension

of the tubercular process to surrounding bone. Irritation of a residual or encapsulated abscess after articular healing does not necessarily tend to extension.

The causes of death from Coxalgia are:



FIG. 302.—Same case. Full extension.

Phthisis Pulmonalis; Tuberculous Meningitis; General Miliary Tuberculosis; Amyloid Disease of the Viscera; Intercurrent Disease as Scarlet Fever; etc., and operation followed by infection or dissemination of the Tubercle Bacilli through the circulation.

The Prognosis as to Secondary Abscess.

In all cases about 25 to 50 per cent. will have one or more sinuses from the joint lesion. In all cases seen at the onset or very early in the disease, but few should develop an extra-osteal abscess provided the treatment is efficient. In a series of cases investigated, comprising both those seen early and old neglected cases at the Kernan Hospital for Crippled Children, abscess was present in 20 per cent., from the analysis of Osterhaus.

Prognosis as to Malposition of Limb.

The ultimate result as to deformity depends upon the severity of the case; time treatment is begun and its efficiency; the retardation of growth; the amount of muscular atrophy, which never entirely disappears even under good massage and electrical treatment later and the amount of permanent muscular contraction holding the leg in a malposition.

Prognosis as to Motion.

In 50 consecutive cases cured at the Kernan Hospital for Crippled Children by traction and analyzed later by Osterhaus and Scott, for the writer, for ultimate results, 32 or 65 per cent. had more than 30° of motion in flexion.

Treatment.

Local remedies are but little used now and have given place to mechanical appliances.

Constitutional Treatment is important, however, with abundant direct sunlight and fresh air, good food and such tonics as cod liver oil, strychnine and iron.

Too much cannot be said in praise of tent, shack or porch life for these cases, as we can testify from an experience of 15 years during the summer months at the Mountain Hospital situated at Blue Ridge Summit, Pennsylvania and 10 years at the Kernan Hospital. Here, in a comparatively short time, the color, nutrition and general condition showed rapid improvement as well as abatement of the local symptoms. Heliotherapy to the nude patient is used when weather conditions permit in spring, summer and fall at the Kernan Hospital. Exposure to direct sun-light is begun by exposing the feet and lower leg for five minutes back and front the first day. The exposure is made to the same region the next day for five minutes and then the thighs, feet and lower legs are exposed five minutes more. Similarly the abdomen and then the chest are exposed increasing the amount of body surface and time by five minutes each day to avoid blistering. The temperature is taken before and after exposure. The eyes are protected by smoked glasses and the head by a straw hat. Blondes and red headed patients do not tolerate the sun's rays as well as brunettes. Fever and headache should contraindicate or shorten subsequent exposures. Practically all tuberculous bone cases are improved by Heliotherapy.

As soon as a diagnosis of Coxalgia has been made, the patient should at once be put to bed in order to give the joint perfect rest and remove the traumatic effect of weight-bearing on the weakened member.

It is not, however, sufficient to put the patient to bed, but he must be recumbent and have *fixation of the trunk, so that the leg may have traction and fixation at any desired angle with the body.* Nothing is as satisfactory for this body fixation as a Bradford frame, to which the patient is strapped. It is nothing short of useless and ridiculous to allow a patient with hip disease to sit up and roll around in bed, thus increasing the "position of flexion" and other malpositions and having all of the disadvantages of confinement with none of the benefits. No half way measures should be used but thorough fixation, to start with, should be insisted on.

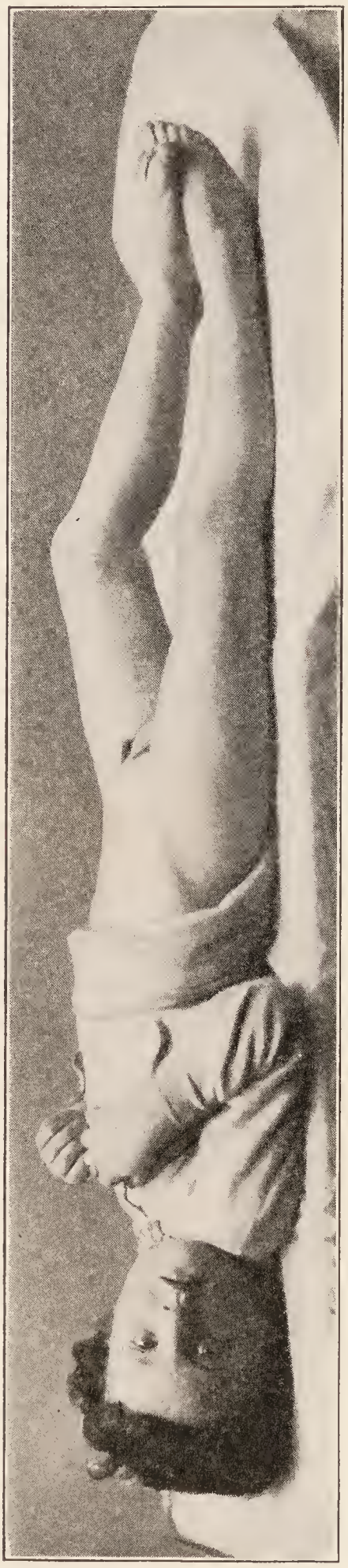


Fig. 303.—Instinctive effort at traction in hip disease. (*Young.*)

There are two methods available in the so-called conservative mechanical treatment to apply to the hip joint itself; one, the Continental Method, which is aimed to *Fix* or *Immobilize* the joint by putting on a plaster of paris spica extending from the Xiphoid Cartilage to the tips of the toes; but in England this is more usually accomplished by means of the Thomas splint, which consists of a steel bar extending from the shoulder blade to the calf posteriorly and conforming to the body's contour and held in place by padded bands around the thorax, pelvis, thigh and calf (Fig. 304).

The second method known as the American Method and the one generally adopted now, as yielding the best results, is that obtained by *Traction* through a Buck's extension apparatus on the diseased leg, but the most important point to be borne in mind in the application of this method is that traction must be made in the "Line of Deformity." By this we mean, if a leg is held in a "position of flexion" of say 45°, traction must be made at that angle by means of an inclined plane made to support the leg, and *not in the plane of the bed*, as is so often done. The explanation of why this yields so much more satisfactory results is easy to understand, for we may consider the contracted psoas muscle like a strong elastic band, which *if relaxed* will allow the intra-articular pressure between the femoral head and acetabulum to be lessened by the traction through Buck's extension. On the other hand if traction is not made in the line of deformity this contracted tense muscle acting against the brim of the pelvis as a fulcrum, when the traction is applied, will tend to jam the femoral head more into the acetabulum and thereby render the symptoms more acute. (Fig. 34.) As the position of flexion is gradually overcome the inclined plane can be lowered until finally the parallelism of the

legs is restored. From 5 to 35 pounds (usually 5 to 15) must be used for traction and at least two months of recumbency and traction is usually required to overcome malpositions of the leg due to muscular spasm and to cause a subsidence of the acute symptoms. Of course, if bony ankylosis is present with malposition, traction will not correct the deformity and operative means, to be spoken of later, must be employed for this condition (Figs. 31 and 303).

In positions of abduction and adduction, it is well also to make traction *in the line of deformity* until the muscular spasm subsides, when by degrees the leg can be brought into its normal position.

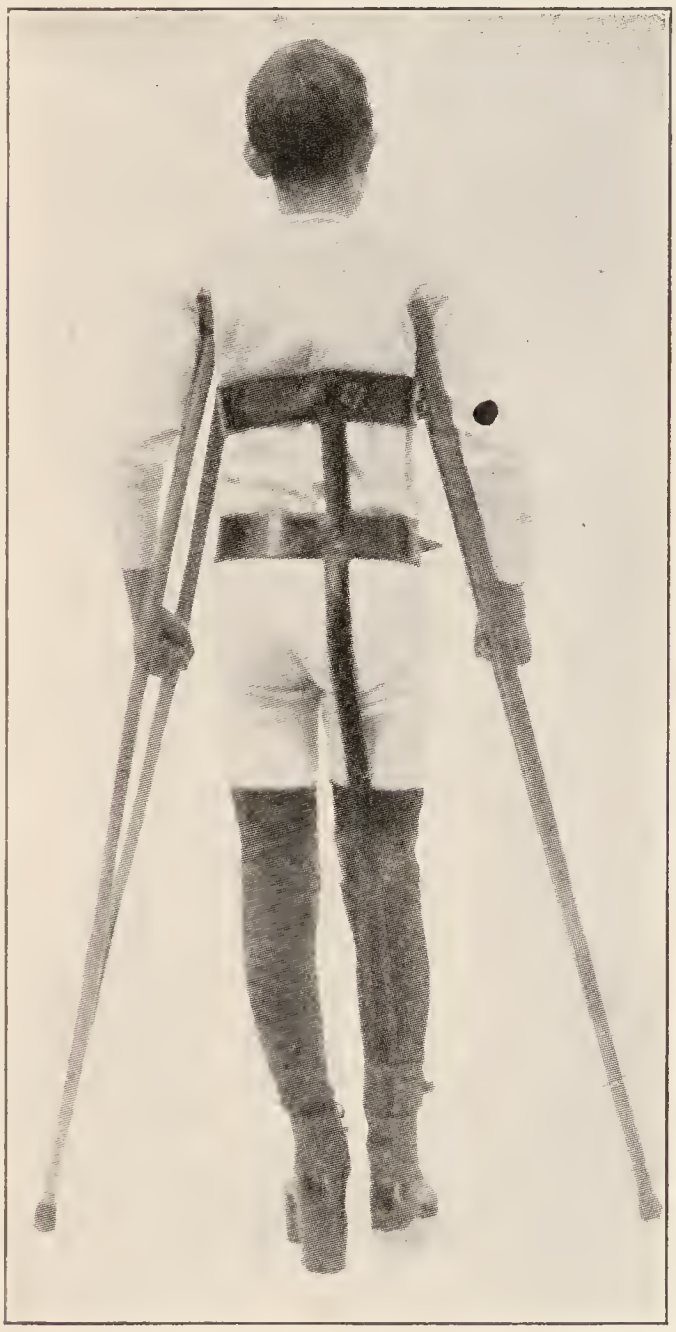


FIG. 304.—Thomas hip splint applied. (*Young.*)



FIG. 305.—Long Taylor traction splint with thoracic band.

When the acute symptoms have subsided after a prolonged recumbency with fixation and traction, and the muscle spasm has disappeared, the joint motions have much improved, all malposition has been corrected and the child's general condition seems good, we can make our arrangements to get the patient up.

If the Continental Method is then used (i.e., either the plaster of paris spica or the Thomas splint on the lame leg), we should have made a cork-soled shoe of sufficient height to prevent the foot of the affected leg from touching the ground and provide the patient with crutches (Figs. 18 and 304).

Spicas of leather or felt or celluloid can also be made from the plaster image of the part, so that they could be laced or taken off at will. These are especially useful for protection after *muscle spasm ceases* to afford protection to the joint, but are too costly and unwise for growing children and are hot.

Lorenz has a steel patten attached to the plaster spica and a high shoe on the foot of the well leg and does not advise the patient to use crutches as he *desires ankylosis* in a good position, but we, in America, cannot agree with this. Little children too small to use crutches may use and walk on the Thomas Knee Splint with a traction windlass at the bottom (Fig. 20).

The American Method continues the Traction after the patient is up by means of braces, known as Traction Hip Splints, which differ in minor details depending on the views of the surgeon employing them. All consist of a pelvic

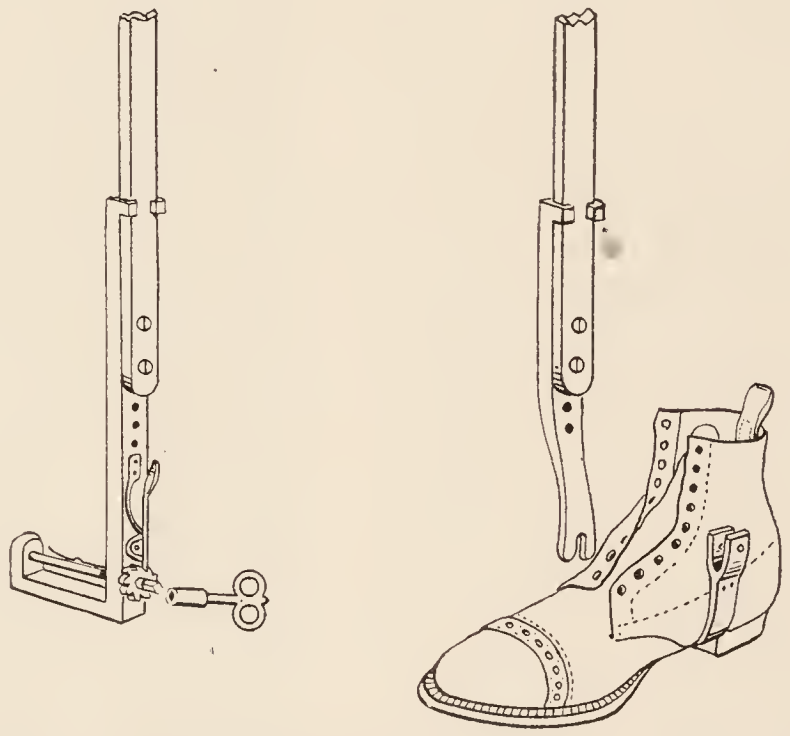


FIG. 306.—Detail of Taylor traction splint showing ratchet, spring, lever, windlass and key. Also convalescent attachment of brace and shoe.

band or ischial crutch of steel and a rod extending down the outer side or both sides of the affected leg and terminating in a piece passing under the sole of the foot. Two perineal straps buckle to the pelvic band in front and behind and passing between the legs make the pelvis a fixed point of resistance and by means of buckles or catches on the foot piece the straps on the leg can be pulled on and so have traction exerted. The C. F. Taylor Traction Splint, which is perhaps the best simple brace, has a windlass and key attachment fastened to the foot-piece by means of which any desired degree of pull may be exerted through the Buck's straps. Sayre's Traction Splint has a solid rod sliding within a Tubluar lateral rod with key adjustment by means of which the rod can be lengthened or shortened and more or less pull made on the leg through the straps fastened to buckles on the foot piece (Figs. 305, 306 and 307).

Phelp's brace was very similar with an external lateral strap traction as well, which aimed and was claimed to pull the femur out laterally near the joint, as well as vertically downwards.

Lovett and Dane have added a spica to the inside of the Thomas hip splint and on the bottom Taylor's windlass traction attachment endeavoring to increase the fixation and the traction of the brace. All traction splints have a supporting



FIG. 307.—Patient showing traction splint, high shoe and crutch equipment.

calf and thigh band. Others have carried the lateral bar up to the axilla and added a thoracic band to prevent the child in sitting from flexing the leg at all. Still others believe that a moderate amount of motion, provided traction is efficient, is not harmful and have a swivel joint at the junction of the lateral bar with the pelvic band instead of a rigid attachment. In the Thomas knee splint used for hip disease and all braces with ischial crutches, no perineal straps are required.

All of the cases wearing the traction splints are provided with crutches and a high shoe to prevent the brace and lame leg from touching the ground.

To compensate for shortening produced by disease and nonuse as well as the known tendency to adduction with its apparent or relative shortening, the author believes in maintaining *slight abduction* both in recumbent and convalescent treatment.

At one time it was thought that fixation of a joint tended to produce ankylosis, but we know now that many tuberculous joints are saved from ankylosis by traction with more or less complete fixation, provided weight-bearing is removed. Pathological specimens showing eroded posterior margins of the acetabulum ("traveling acetabulum") go to prove that muscular spasm causes this extension of the disease and traction is to be used while this symptom is present (Fig. 298).

When a child has worn a hip splint for a year or more and all acute symptoms have subsided, including muscular spasm, and joint motion seems as free as the amount of damage done by the disease (shown by the X-ray and history) would permit, then we may consider the advisability of allowing the child to discard the adhesive straps and brace and have a plaster spica to the foot or knee and continue the crutches and high shoe.

The next step in advance may be taken by discarding the high shoe and shortening the crutches. Next, the crutches are discarded and finally the protecting spica. Each one of the changes require an interval of six months to be on the safe side.

It can readily be seen that when a child wears a long traction splint, which holds the leg in full extension with the body, that it is an impossibility for such a case to sit down on a chair in the ordinary manner. They are forced to sit on the buttock of the well leg on the side of the chair, with the foot of the disabled leg and brace resting on the floor beside the chair. For this reason, in many cases, it is advisable to have a special chair constructed for them, which can easily be done by having one-half of the seat (corresponding to the disabled leg) cut out simply leaving a strip between the legs of the chair around the back, to make them secure and then having a board run from the back to the lowest front rung of the chair to support the disabled leg. The remainder of the seat and the inclined board can be padded or covered to afford a comfortable support for these patients in the sitting posture at meals, etc. The ordinary all-wood kitchen chair is the best to adapt for this purpose.

Treatment of Night Cries.

This symptom which is distressing to parents and indicative of the acute stage of the disease to the surgeon, is best combated by (1) raising the traction *in the line of the deformity* to relax the psoas and by increasing the amount of

weight if necessary; (2) firmer fixation of the body on the bed frame and seeing that the spreader or some knot in the rope does not come in contact with the pulley at the foot of the bed, thereby abolishing the steady pull; (3) *the weights are to be lifted as little as possible* in examining the case, in changing the bed linen or bathing the patient; (4) where none of the foregoing are helpful a blister of Cantharideal Plaster or Collodion about an inch square is to be used just anterior to the Trochanter Major; (5) Bromides and Asafoetida are sometimes an aid to the mechanical treatment where muscular spasm is a marked symptom. Morphine and the preparations of salicylic acid are less satisfactory and the former should never be used habitually and has never been employed by the writer for this purpose; (6) Igni-puncture by the Paquelin or Galvano-Cautery or drilling and tunneling (Davis) through the Trochanter Major into the Femoral Neck and focus of the disease have been reported in intractable cases as yielding good results; (7) exploration of the joint for sequestra and epiphyseal separation will be spoken of more at length later under operative treatment of Coxalgia.

Persistent night cries resisting nearly every form of treatment usually indicate acetabular disease or sequestration which a clear X-ray negative will often confirm.

Treatment of Abscesses.

In Coxalgia abscesses are unfortunately common, some 25 to 50 per cent. of all cases seen presenting them, but by no means all of them open spontaneously nor is it necessary nor expedient in all cases to incise and evacuate them with the knife, for many are absorbed.

Further, if we bear in mind that the contents of these abscesses are practically serum and broken down bone tissue, its absorption in the part can do no harm; and, on the other hand, if these abscesses evacuate themselves or are incised pyogenic skin cocci will invade the tuberculous abscess. Near the genitals or rectum, there is the greatest possibility and likelihood in childhood of the resulting sinus becoming infected with colon bacilli and streptococci. Secondarily, the bone focus becomes involved in a double infection with disastrous results to the general system from hectic fever and pyaemia with amyloid visceral changes, if prolonged.

Thus two alternatives are open to us for cold abscesses in general (1) the so-called conservative treatment or "let-alone" policy and (2) puncture with a large trochar and closure or incision, evacuation, drainage and suturing. Judgment is required to determine the proper course to pursue.

I. The Conservative Treatment is justified if the abscess is small, if the other joint symptoms are slight, showing a tendency to improvement and if the general health is good; if the abscess has burrowed near the genitals or rectum when tight strapping or bandaging can be used to force it towards the outer side of the leg and cause by pressure the occlusion of the inner abscess cavity. We may trust to nature for a time at least to effect absorption.

II. The Operative Treatment is indicated if the abscess is large, is burrowing in various directions undermining the soft parts, is increasing in size and is painful and the joint symptoms are acute; if a thin membrane of parchment-like skin covers the abscess cavity, which seems about to evacuate itself "to

save the bed clothes" and when there is less possibility of the skin cocci infecting the tuberculous cavity and the abscess is well situated on the external, anterior or posterior aspect of the joint.

The same aseptic and antiseptic precautions are to be taken in incising a tuberculous abscess, that one would use for *any clean operation*, the tuberculous debris and pus is to be evacuated, the cavity wiped out with gauze, but not curetted. Then a continuous subcutaneous suture of silver wire is put in and the wound is tightly closed and compression again applied. The idea of this early suturing is most important to prevent secondary infection, which, even with the most pains-taking care, will often take place if suturing is too long delayed. The temperature chart and pain will give the first warnings of a secondary infection, which if present the wound should be opened, left open and drained as is done in all acute abscesses.

The use of an aspirator to draw off the tuberculous pus is most unsatisfactory, as even the largest needles become plugged with the flocculi or bits of bone debris, thereby preventing the egress of the more fluid parts. Further, if repeated aspiration is done, there will be a tendency for the abscess to open at the point of puncture, where a road of weakened resistance is made. Calot, however, advocates this strongly.

Some have employed aspiration followed by the injection of antiseptics or absorbents into the abscess cavity. This is not done by the highest authorities now. Carbolic acid has been used for this purpose with fatal results; iodine, with questionable benefit and *the iodoform emulsions are generally now considered by those best able to judge as simply foreign bodies, which do little or no good*, when thus employed.

Of the operative procedures for the treatment of cold abscesses, the knife is by all odds the most satisfactory means to employ. The surrounding surfaces of ordinary uninfected tuberculous sinuses are best wiped clean with alcohol, then dried and covered with dry sterile gauze. For secondarily infected sinuses, Iodoform Bougies have been extolled. Similar to our experience with iodoform in oil injected into joints, Beck's Bismuth Paste has no longer the vogue it had, for like the sky-rocket, we know "whatever goes up must come down." Bismuth exudes for months and even a healed sinus may reopen to let Bismuth out. Hypertonic Salt Solution as a "Tidal Irrigation" described at length under Pott's Disease is the "last word" on treatment for sinuses and the best.

Correction of Deformity.

Deformity resulting from hip disease is a malposition of the limb, which prevents the voluntary or passive restoration of a limb to a parallelism with its mate. This malposition manifests itself as a flexion, abduction or adduction simply or as a combination of the first with one of the other two. Of these, abduction, in that it causes an apparent lengthening of the limb, compensating thereby the atrophy in length produced by disease and bone destruction, is the least detrimental to functional use and should be aimed at in treatment and is really desired *in a moderate degree*. Flexion and adduction are the malpositions requiring correction on account of the "apparent" or relative shortening produced by them.

Such deformities occur from muscular spasm, contracture of the soft parts (tendons, muscles, ligaments, etc.) owing to adaptive shortening from prolonged malposition or bony ankylosis in a vicious attitude, which accompanies the imperfectly treated healing process.

Of course, the treatment must depend on the pathological state, which is to blame for the deformity; in the earlier stages, where muscular spasm is the chief element in producing the malposition, traction in the line of the deformity will gradually correct the trouble. Later, when contracture, adaptive shortening and bony ankylosis are present, traction accomplishes nothing.

Permanent contractures may be overcome under anaesthesia by forcible stretching; suddenly as one usually understands "Brisement forcé" as advocated by Lorenz (not gradually applied) but if any bony ankylosis is present, the author has had unpleasant experiences with it and advises against its use. This stretching in fibrous ankylosis and muscular contracture can be aided by subcutaneous tenotomy of the Adductors, Tensor Vaginae Femoris, Sartorius and Quadriceps tendons and myotomies if necessary with manual correction followed by putting the whole leg and trunk in a plaster of paris spica bandage with the limb at an angle of 20 to 30° of abduction, to allow for any subsequent contractures and produce all the compensatory and apparent lengthening possible. The exact angle of abduction used in spica fixation depends largely upon the extent of the original deformity and the surgeon's judgment from experience, as well as the age and size of patient.

Gant's Osteotomy.

In bony ankylosis of the hip joint in a vicious position, osteotomy must be done and of the many operations advised, that suggested by Gant is the most popular in this country. This operation is performed subcutaneously by driving an osteotome three-fourths through the bone at a point below the Intertrochanteric Line, so that the contraction of the psoas muscle cannot cause the lower fragment to override the upper and is not to invade the old tuberculous focus, which the higher operations are said to do, and rekindle the activity of the healed disease. Lorenz claims this is more of a fancy than a reality and he has never seen his operation for this condition, to be spoken of later, start up the disease again; but it may cause a slight elevation of the temperature (102°—3° F.) for a few days with a better functional result and more lengthening from the fact that the Gant is an eccentric operation and not done at the centre of motion. There is no contradicting the fact that when an adducted thigh is abducted after a Gant operation a curve is produced by the resulting bone union thereby shortening the true length of the femur, which the abducted position and downward tilted pelvis must compensate for. Nevertheless the Gant operation is the operation of choice and the results are most satisfactory and often brilliant (Figs. 308, 309 and 310).

The Gant operation is done as follows: The Trochanter Major is found and two or three inches below its summit the osteotome is driven through the skin with its cutting edge parallel with the long axis of the bone to avoid cutting across superficial vessels, if possible. When the periosteum has been cut through, the osteotome is rotated through an arc of 90°, so that its cutting edge is at right

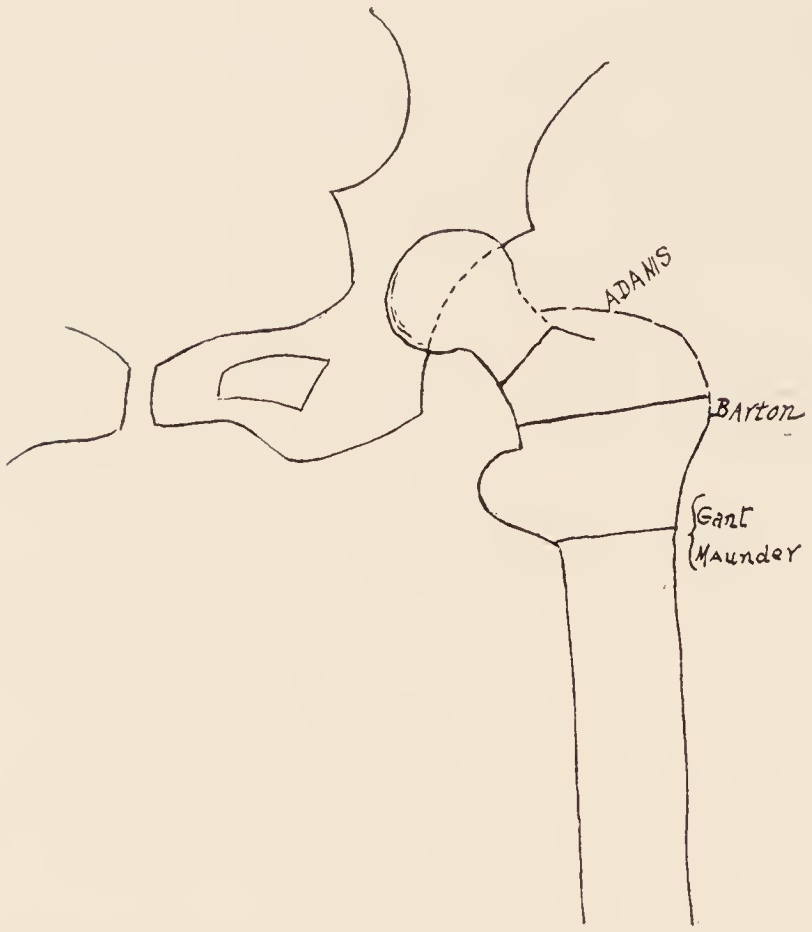


FIG. 308.—Diagram of different forms of osteotomy for ankylosis of hip. (*Young.*)

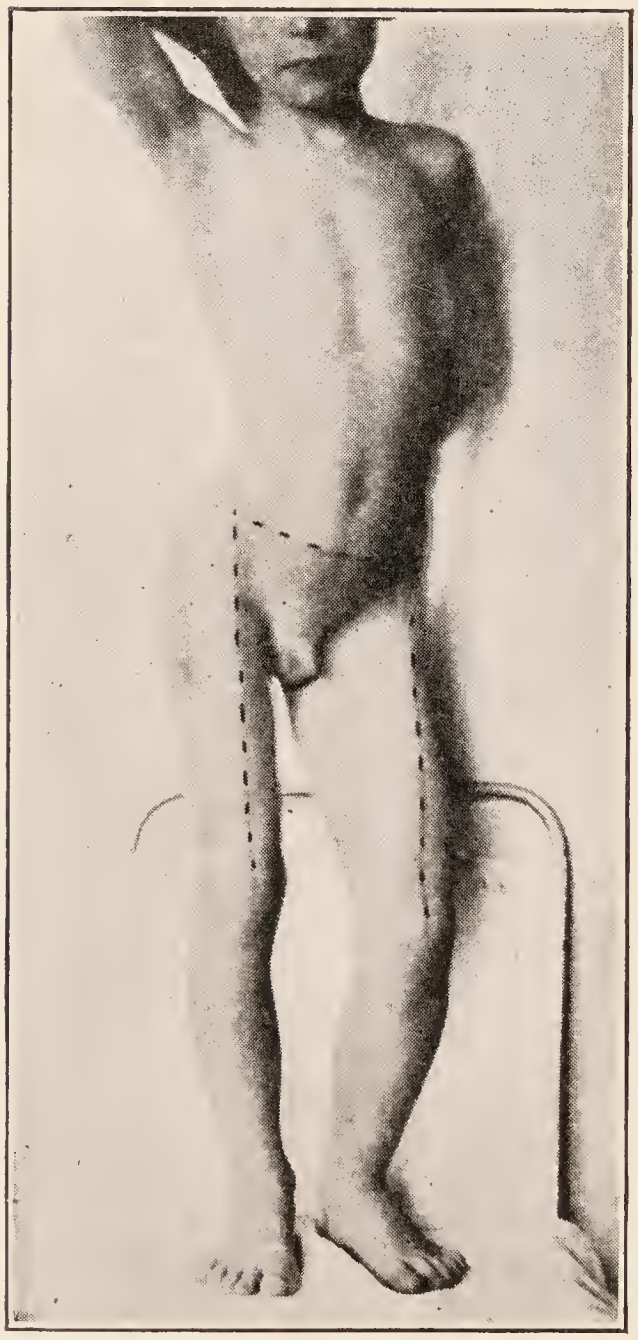


FIG. 309.—Adduction and shortening before Gant osteotomy.

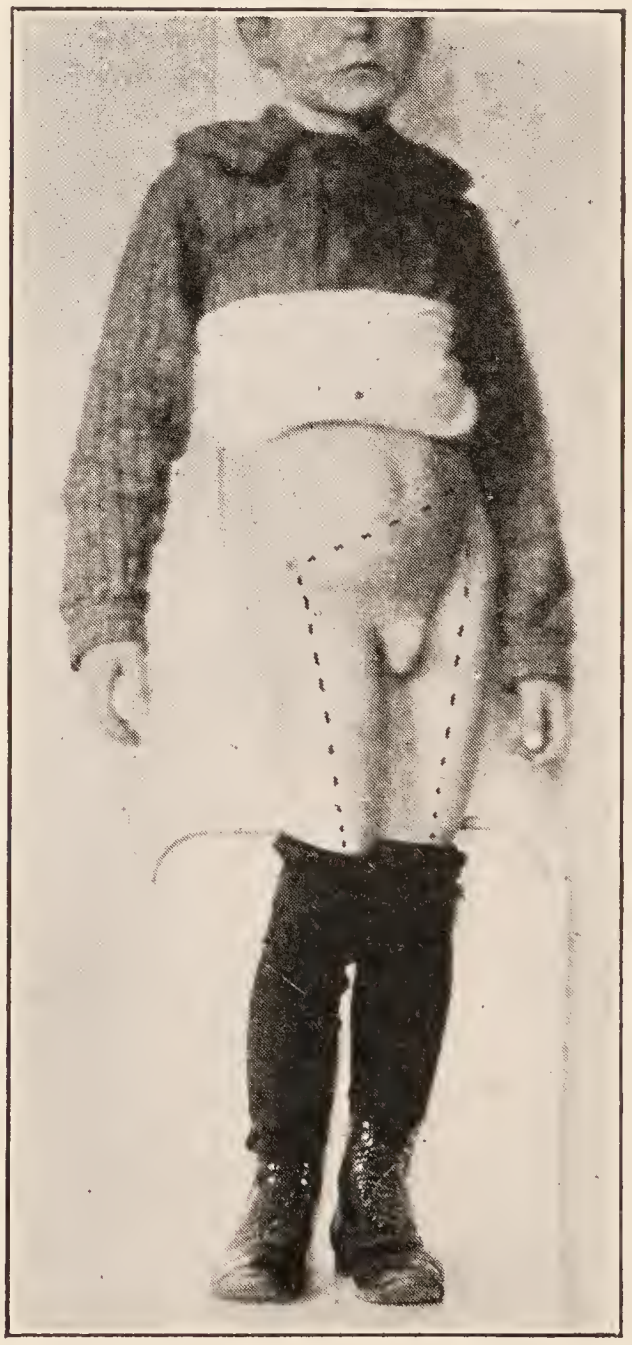


FIG. 310.—The same after osteotomy with abduction.

angles to the shaft of the bone. It is then driven by the mallet in a slightly oblique direction downward and inward corresponding and parallel to the Intertrochanter Line. Before beginning the operation, by means of the centimeter scale on the osteotome and by palpation, the thickness of the femur at the proposed point of section should be determined and one easily then can tell when the section has gone one-half or three-quarters through the bone by watching the scale. Fracture inward can then be made at the desired point without cutting entirely through the bone, which it is not necessary or desirable to do, for a hinge of bone is thus left, anchoring the fragments together partially.

As the chisel is driven in, the operator should make his cut in the bone rather fan-shaped, so that it will be wider as he advances and there will then be less liability of the osteotome becoming wedged in the bone. The osteotome should only be moved in a direction corresponding with its cutting edge for otherwise, the instrument may be broken off in the bone.

When the section has gone one-half to three-quarters through, the bone fracture is easy by extreme *adduction* of the leg, after which the flexion can be overcome, the leg can be carried into the desired *abducted* position, impacted and there held for six to eight weeks by a plaster of paris spica to the toes, previously described. As the majority of these cases relapse more or less, it is advisable to continue the use of a short spica from the waist to the knee maintaining abduction for six or more months.

The transverse linear osteotomy just below the Trochanter Minor is advised by many and Bradford has reported a case of fatal hemorrhage following the oblique linear osteotomy from *just below* the Trochanter Major toward the Trochanter Minor.

Lorenz believes in making a skin incision of about six centimeters long in the long axis of the leg beginning about two centimeters below the anterior-superior Spine of the Ilium and just internal to it. This brings one, after incising the fascia lata, to the inter-muscular space on the medial side of the Tensor Vaginae Femoris. By separating the muscles and incising the capsule, one can see or the finger can detect where the head or neck of the femur is ankylosed to the acetabulum. Section is then made at this point by an osteotome.

Most American surgeons dread the possibility of rekindling the tuberculous process or disseminating the tubercle bacilli and hence few have as yet followed Lorenz. Hoffa, of the foreigners, also favors the high operation, but has not gone to the joint as Lorenz has done, but keeps as close to the Trochanter Minor as he can. Brisement Forcé or forcible breaking up of an ankylosed hip in a malposition is to be avoided as two cases in the author's experience resulted fatally from the bacilli through the lymphatics or veins, causing meningitis.

The Operative Treatment of Coxalgia.

The mechanical treatment, preferred by the majority of Orthopaedic surgeons, has yielded very satisfactory results, although tediously obtained. The early efforts at operative interference, before and after the introduction of aseptic and antiseptic surgery chiefly directed to excision of tuberculous joints, resulted in wound infection, dissemination of the tubercle and an extremely *shortened limb, from removal of the epiphysis in children*, and an insecure joint, if

not an ankylosed one. Hence those who saw large numbers of these cases, which had had excisions done, with unfavorable results and compared them with those treated mechanically were and still are accustomed to condemn all operative methods. Consequently *excision* has practically been discarded and abandoned as an unscientific surgical procedure in treating tuberculous joints in children. Surgical means other than excision have been employed as follows:

1. Aspiration of the joint fluid and the injection of antiseptics, chiefly Brun's solutions or emulsion of iodoform in glycerine, in olive oil or in ether and also iodine, carbolic acid and bichloride of mercury have had advocates. These procedures are no longer popular and not used by the best Orthopaedic surgeons, who found that the iodoform emulsions did not shorten the duration of the disease nor alter the course of it *in any way*. Many consider the iodoform so injected as simply a foreign body in the joint and not coming in direct contact with the disease, unless the tuberculous osteitis has become an arthritis. As a routine method of treatment, *it is now obsolete*. Particles of iodoform if used, may be extruded through sinuses for years after healing by other methods.

2. Ignipuncture is also an old method used with the idea of arresting the tuberculous process. The actual cautery is thrust into the trochanter major and up into the neck towards the joint in an effort to burn out the disease and relieve the intra-osteal tension (Vide *Supra*, "*Treatment of Night Cries.*")

Trephining and drilling through the trochanter was used with the same idea in view. With these, the author has had no experience.

3. The aspiration of abscesses and their injection with antiseptics has already been spoken of under the head of abscesses; also the incision of abscesses.

Erasion.

4. We now come to erasion of the tuberculous focus by curette, gouge or chisel. It has been stated repeatedly that the erasion of one focus would only be a part of what should be done, as it is impossible for an operator always to see all of the foci of disease or, for that matter, in the hip of a small child, to see any focus of disease, in the hip joint, without sacrificing muscular tissues by large incisions and much healthy bone. Others have claimed that the joint lesion is but a small part of the *general tuberculariz̆ed state of the individual*, which must be minimized, as a first consideration by tuberculin, fresh air, sun, food and tonics.

Further, a surgeon would infect fresh surfaces with disease at the time of the operation, it has also been claimed.

Again, in an early case with a caseating tubercle, deep in a bone, the operator has been compelled to go at it blindly through a healthy cortex or by aid of the cautery in such procedures as the Akido-Peurastik of Middledorf to detect the diseased softened focus. From pathological knowledge, it may be briefly stated that the initial focus of disease is in the femoral neck and head near the epiphyseal line usually, and if not there, then he is to look, after removing the sound head or part of it, into the acetabulum; the synovial membrane being usually secondarily affected only after the process has burrowed from one of the above named bone foci into the joint.

What are the objections to this operation? The objections in former times made to excision were, first, the danger of wound infection; second, the dissemination of the tubercle; and third, a shortened limb and insecure joint, if not an ankylosed one.

The author feels, in respect to erasion that, with our present surgical technique, we can disregard the first objection as being a thing of the past, for now we have primary union.

Second, the dissemination of the tubercle, in suitable cases, that is, in those whose vitality is not in a wretched state from prolonged disease and suppuration, is as Phelps put it, more of a "bug-bear" than a reality, especially if we are cautious in choosing the least bloody route to the focus; in keeping our wound as dry as possible, and clamping or occluding all bleeding points immediately, with thorough flushing with *hot* salt or sterile water and wiping out of the diseased debris with sterile gauze. The author has yet to see a case in which he could attribute general miliary tuberculosis, tubercular meningitis or other metastasis to the operation; in fact he has had no such mishaps except with Brisement forcé, which we can well understand would tear a tubercular focus and rekindle the process without the removal of the cause.

The third objection a shortened limb etc., need not hold in an *erasion*, as it does in *excision*, for in the former, after locating the focus by means of the X-ray, we need only remove *it* with the curette, without taking the entire epiphysis of the head away, as was necessarily done in excision. Stimulation of the epiphysis may even result.

Even granting that our skiagraph shows us that the whole femoral head has undergone caseation and disintergration or that separation has occurred in the neck (a pathological excision or epiphyseal separation) would anyone expect the normal rate of growth and perfect function to be obtained by leaving it in the capsule? Such removal and disinfection of the joint could but hasten healing. Which of us with a neglected and advanced condition such as just described, would not prefer an ankylosed hip joint at once to one that would have a number of discharging sinuses with possibility amyloid changes for years, and ultimate ankylosis.

Now, what are the advantages to be gained by erasion and disinfection? First, the removal of the cause of the *local* disease. Second, the shortening of the duration of the disease. Third, the arrest of the spread of the disease. To use Phelps' extreme expression of a joint, "macerating in pus," we may consider from clinical experience, the possibility of partial or total joint destruction ensuing, with partial or total abolition of joint-motion and shortening, if the advancing disease is not checked early. The advantages named are simply ideal and too optimistic, but even granting that, should they not be our chief aims in treatment?

There are no available statistics of simple erasion in tubercular joints and to form an opinion of its value we could not apply those from excisions and some years will be needed to form final judgment.

The author feels that erasion, with modern surgical technique back of us, must give a lowered mortality; and by the removal of all or a large part of the disease, the duration must be shortened and the extension of the disease minimized.

The author has adopted the following plan of procedure in performing erasion (Figs. 311 and 312).



FIG. 311.—Tuberculosis of right hip before erasion.

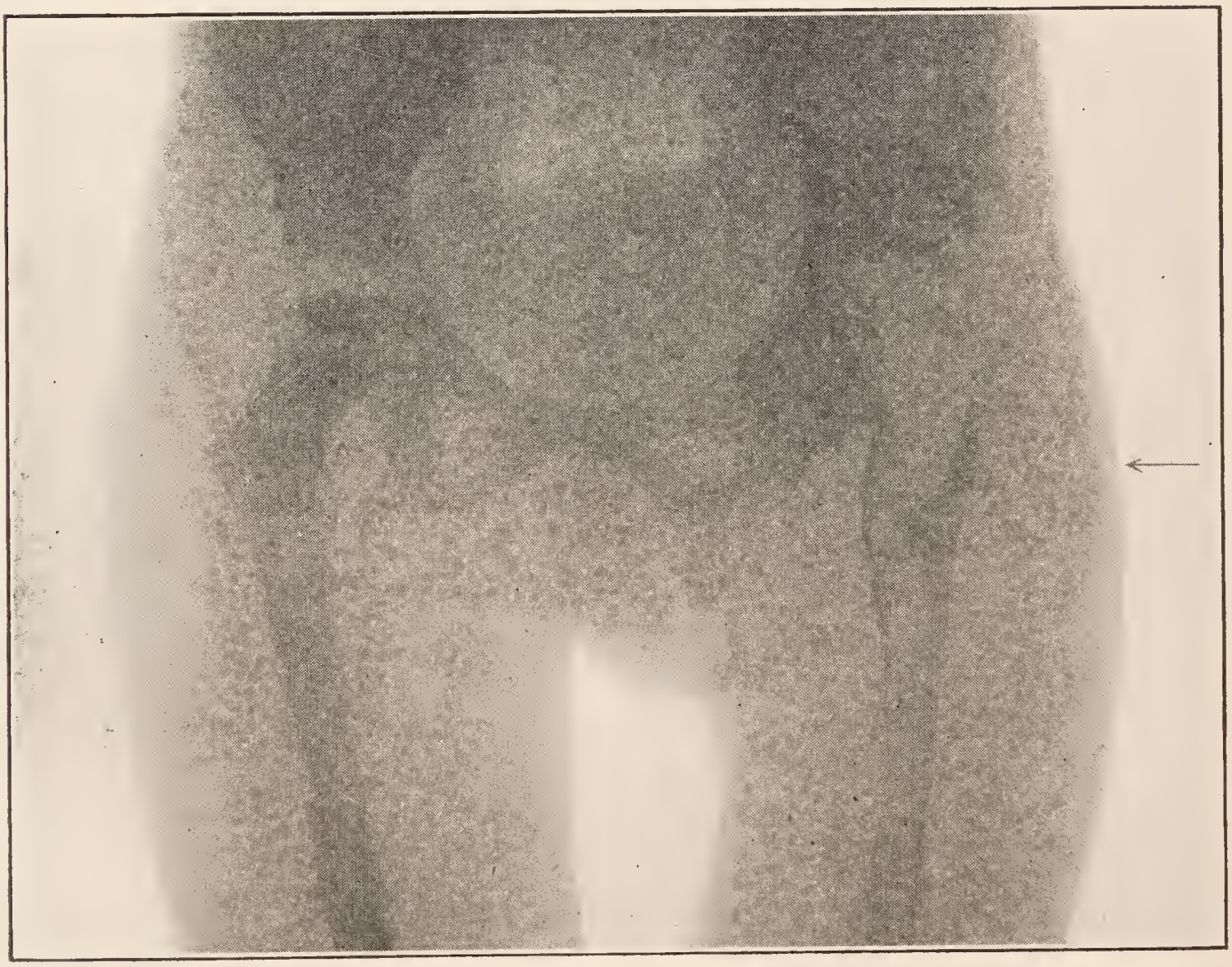


FIG. 312.—The same after erasion.

Preparation for the Operation.

The majority of the patients are admitted with a position of flexion or malposition and are put to bed with traction in the line of the deformity. This is maintained until the parallelism of the legs is restored and the acute symptoms have subsided. It is then possible to obtain a good skiagraph, which was, of course, not the case when the leg was flexed, as the true relations of bone shadow to plate are often distorted.

The Operation.[1]

1. **Choice of Cases.**—With our skiagraphs, history, position and motion records before us, we can distinguish the exact condition of the joint and determine on the best method of procedure as follows: In beginning cases where the focus is very small indeed, well within the bone and not encroaching on the joint surfaces, we can at least leave these to the conservative methods of *rest, fixation and traction* in the hope that nature assisted by out-of-door life, in tents or shacks preferably, sun-shine, good hygiene, tuberculin and tonics will arrest the disease and furnish a strong fibrous wall to resist further inroads of the process, as we all know, *it is possible to obtain a cure* in such early cases. Such cases should have X-ray examinations made from time to time *to be sure* that there is no extension. If close to the joint together with persistent acute symptoms, then operation must be done without delay.

If a case has *numerous sinuses* when first seen, which are secondarily infected, the patient's condition is bad and the skiagraph shows extensive joint destruction nothing can be gained by erasion (nor by excision for that matter, as Barker pointed out) and our best plan is to lay the sinuses wide open and overcome the secondary infection as soon as possible, by antiseptic fomentations, "Tidal Irrigations" etc., leaving the original trouble to conservative methods. Experience has taught us the practical impossibility of helping these cases by extensive operation, on account of the prolonged suppuration that usually follows, with hectic fever and amyloid changes. Thus it will be seen that the author urges from his experience the operation of erasion on what we might call those of moderate bone involvement, which are getting worse, or the middle class of cases.

2. **The Choice of Incision.**—Of course, the incision for an erasion differs from that needed for an excision, but that first used in 1878 by C. Hueter for excision and bearing his name, and a little later used by R. W. Parker independently (Brit. Med. Jour. 1888, Vol. I, page 1325) known as the "anterior incision" the author has found most useful. He has also used White's or Langenbeck's lateral incision but he has had no experience with Cheever's, Ollier's or Sayre's. Where the abscess was evidently on the posterior aspect of the joint, he has used Heyfelder's posterior incision (Bradford and Lovett, Orthopaedic Surgery, 1st Edition, 1890, pages 339 to 344).

The anterior incision which is to be preferred, is made in the following way: beginning at the anterior superior spine, make an incision vertically down the limb through the skin for four or five inches; then through the fascia lata, one can see the intermuscular space between the sartorius and rectus on the medial side

[1] R. T. Taylor, Transac. Am. Orthop. Assoc., vol. xv. p. 232.
Ibid., vol. xvi, p. 143.
Ibid., vol. xviii, p. 34.

and the tensor vaginae femoris and gluteus medius on the lateral side and this space is laid open. This brings one down on the capsule, which can be opened vertically in the line of the incision or at an oblique angle upward and inward, injuring the Y-ligament as little as possible, in laying bare the femoral neck and head. The anterior incision brings one closer to the head and neck, than any of the other incisions, owing to their direction being forward as well as inward and upward. With the X-ray negative in a window of the operating room, the surgeon can locate the focus of the disease and then make his incision, retract, look in the wound, or in very small children feel for the softened focus. When found, one usually has to begin with a small curette and then gradually employ larger and larger ones as may be necessary. The strong, round irrigating curette described by Willard (Trans. Amer. Orthopaedic Assoc., vol. ii, 1889, page 145) will be found useful.

Cleansing of Cavity.

When all possible diseased tissue has been removed, curetted as thoroughly as can be, and if necessary, healthy bone for about a millimeter all around the focus of disease cut away, the joint is thoroughly flushed with hot normal salt solution or sterile water; and in the case of much bleeding, with hot 1–1000 bichloride for its astringent effect to occlude the absorptive vessels as well as for its antiseptic value.

The joint is then dried with sterile gauze and in earlier cases, the author followed Phelps' suggestion of using "pure" carbolic acid and filled the joint with it for one or two minutes to kill any remaining bacilli and followed it with alcohol. This method of disinfection, the author has abandoned, however, as he had a child practically die instantly on the table from carbolic acid poisoning, notwithstanding the free local use of alcohol and other methods of general stimulation. This fatal case was possibly from some large absorptive vessel taking up the carbolic acid as soon as it was put in the cavity. It may have been a case of fat embolism, but the symptoms were not those of fat embolism and were synchronous with the application of the carbolic acid.

He now uses for this purpose the saline or bichloride or a 10% solution of formalin obtained from the commercial 40 per cent. stock solution. This strong antiseptic has, as is well known, caustic, deep penetrating powers and is left in the joint for five minutes, when the latter is again thoroughly dried. A small wick saturated with tincture of iodine or preferably sterile gauze is placed in the wound, reaching to the bottom of the cavity for 24 hours. No sutures are taken in the capsule but the fascia lata is sewed up by continuous or Glover's suture of silver wire or cat-gut, which is brought out of the ends of the skin wound. The skin is then sewed *tight* by a continuous subcutaneous suture of silver wire or chromic cat-gut. These sutures pass around the wick of gauze, if used, which last is perhaps unnecessary except to allow the escape of serum or hemorrhagic discharge which is never abundant. The wound is then covered by silver foil and ample gauze dressing. The child is put on a Bradford frame and five or more pounds traction is used. On the second day, the wick, if used, is withdrawn; and on the tenth day, the silver sutures are taken out and the wound is found dry and healed primarily.

The fixation on the Bradford frame with sand bags and a small amount of traction are important after the operation in giving thorough rest and fixation to the part, protecting it from traumatic motions and positions. Thus we can expect the healing process after the disinfection of the joint to take care of and destroy any remaining bacteria assisted by circulatory changes due to the operation.

This recumbency and traction should be maintained for eight or more weeks to allow ample time for repair and then the patient is allowed to get up with a long traction splint, high shoe and crutches *just as though we were treating an early case of coxalgia.* At the end of six months or a year, if all symptoms have subsided, the brace, crutches and high shoe can be cautiously discarded, in the usual manner and substituting a convalescent splint or plaster of paris spica.

It is this *after-treatment* of traction following the operation that the author has called the "combined treatment" of coxalgia, and which is essential in order to obtain the best results. Huntington of San Francisco advocated going through the greater trochanter and thus avoid entering the joint in metaphyseal disease, and the writer has been pleased with this method in selected cases. Early X-rays naturally guide us in locating the exact region of the bone involved, whether epiphyseal or metaphyseal or acetabular.

Amputation.

Amputation can be dismissed in a word. It should never be employed unless all other means fail to arrest the disease and to save the child's life, but a case so bad as to require amputation, will probably die anyway.

Records.

The records of all hip cases should be taken every two weeks or once a month, at any rate, during the first year and at longer intervals later, and one of the following printed slips filled out at each visit will be found convenient to file away with the remainder of the history of the case and to note carefully the progress of the disease.

RECORD OF HIP MEASUREMENTS

Name.....Date.....
History No.....
Length from Ant. Sup. Spines.....R.....L.....
*Length from Umbilicus.....R.....L.....
*Distance between Spines.....
Adduction.....Abduction.....
Position of Flexion.....
Circumference of Thigh.....R.....L.....
Circumference of Calf.....R.....L.....
Amount of motion:
In Flexion.....
Abduction.....Adduction.....
Rotation-out.....in.....Temperature.....
Remarks.....
.....
.....
X-ray Findings:.....

* After the amount of abduction or adduction has been calculated from Lovett's Table, it should be put down in degrees and these measurements crossed out.

CHAPTER XVIII

NON-TUBERCULOUS DISEASES OF THE HIP

Coxa Vara.

Coxa Vara is a changed relationship in the angle that the neck makes with the shaft of the femur in a lessened direction. Normally, in the adult the neck forms an angle of 125° with the body of the bone, but this varies in different individuals depending upon the width of the pelvis and the height of the person. In the female, this angle approaches more nearly a right angle on account of the increased width of the pelvis. In infancy the angle is more obtuse, but decreases as old age is approached. In addition to the neck projecting in an upward and



a *b* *c*

FIG. 313.—*a*, Coxa vara; *b*, normal femur; *c*, coxa valga. (*Wistar Institute of Anatomy.*) (*Young.*)

medial direction, it also normally is directed forward in relation to the transverse diameter at the condyles from 12 to 14°. Deviation from these two angles, namely 125° and 12° is pathological. If an angle is more than 125°, the condition is known as Coxa Valga. If it is near a right angle or even less than a right angle, it is known as Coxa Vara (Fig. 313).

Etiology.

Various causes have been attributed to the production of this condition. For example, fracture of the neck of the femur, whether intracapsular or epiphyseal separation of the head, late rickets, just as we see cases of knock-knees or bow-legs, scurvy or syphilis. Impacted fractures also may give rise to this condition and it is seen also in congenital hip dislocation from prolonged absence of the head from the acetabulum. In all cases of Coxa Vara, the trochanter major is above Nelaton's line. Just as in Infantile Rickets, anterior and lateral bowing of the tibia, fibula and femur occur, so in children in the second decade, this affection is more common, suggesting an "adolescent rickets," from the ninth to the eighteenth year. (Fig. 319.) It has also been described as a congenital malformation. It is more commonly seen, however, following injuries causing an impacted or greenstick fracture. Two-thirds of the cases are unilateral and one-third are bilateral.

Pathology.

The gross pathology shows more commonly a flexion of the neck downward and backward so that the normal angle of 125° upward inclination is lessened, as well as the angle of 12° forward projection. As a result, the head remaining in the capsule causes the shaft of the bone to be rotated outward, therefore, the foot is more often everted. When in the rarer cases the neck is deflected forward and the angle is increased more than 12° in its relation to the shaft of the bone, the foot is usually inverted. As a result of the first named changes, the whole head of the bone does not articulate with the acetabulum in the usual manner and is partially subluxated. The lower portion of the capsule is tightened from the increased distance between the acetabulum and the trochanter, which, as a result of the neck approaching a right angle with the shaft is at a greater distance from the mid-line of the body and, therefore, the trochanter in these cases stands out in a conspicuous manner. The neck of the femur impinges on the rim of the acetabulum or the side of the ilium when abduction is attempted much sooner than in a normal individual. Flexion and outward rotation are similarly less than normal in the more common variety of this affection. Grossly, we must distinguish also from our X-ray studies, from specimens obtained at post-mortems or from those seen on the operating table, two conditions: first, a Cervical Coxa Vara due to fracture or softening of the neck and, second, Epiphyseal Coxa Vara from separation or partial separation of the epiphysis. The latter is much the more common. When we come to consider the hypothesis that Coxa Vara is a manifestation of Rachitis, in only 33⅓ per cent. of cases examined will symptoms elsewhere of this disease be manifest. In this variety it is thought that probably the rachitic change in the femoral neck occurs at the same time that distortion of the knee or leg bones, leading to bow-legs or knock-knee, and is overlooked. This should point to the importance of getting an X-ray picture of the hip joint, also in these other conditions. In rachitic infants and young children, the neck of the femur is so short and strong and the diaphysis so pliable that the deformity of Coxa Vara is less likely to occur or is overlooked. In the latter case the disability may increase in later years from this early change, which produced a mechanical

distortion or changed internal architecture in the neck at a time when the shaft of the bone soon became very strong, hence, being detected late is attributed to the so-called Adolescent Rickets. The distortion of bow-legs or knock-knees does not tend to produce a changed relationship between the component bones at the articulation as in Coxa Vara, where we see a tendency to either subluxa-

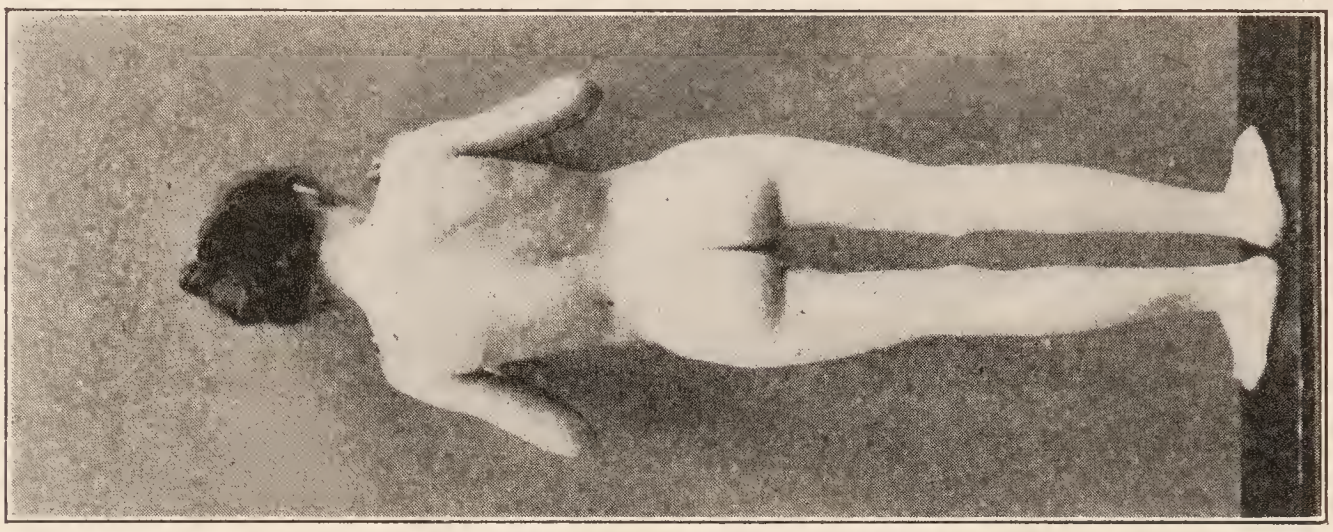


FIG. 316.—Same, posterior view.

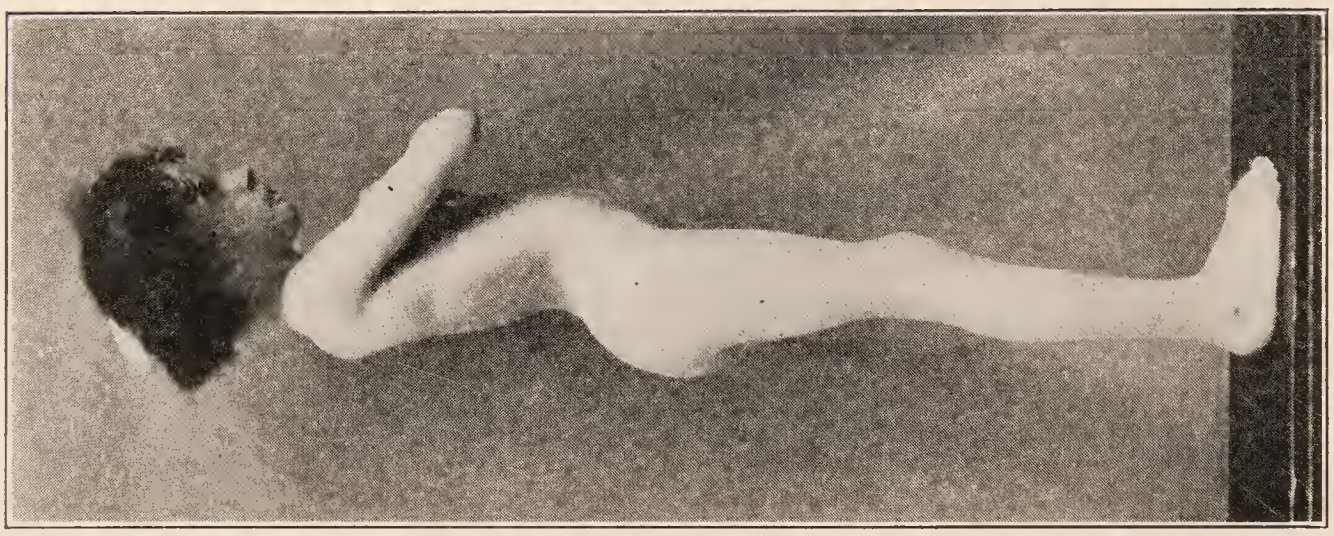


FIG. 315.—Same, lateral view.

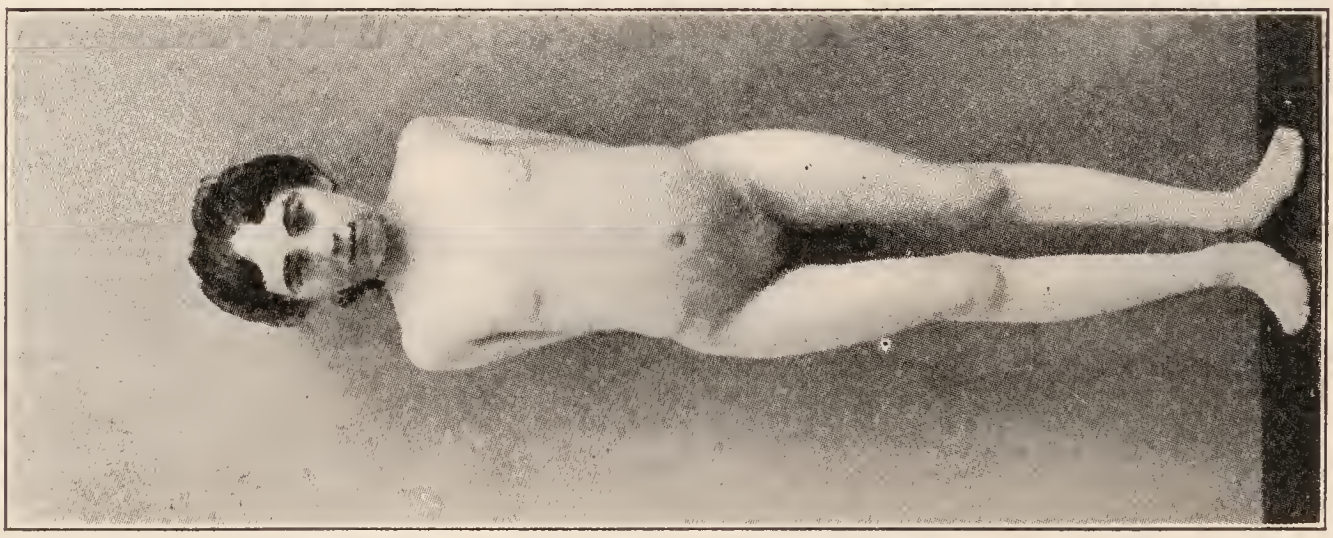


FIG. 314.—Coxa vara, front view. (*Robert Jones.*)

toin or a partial dislocation. On section of the bone, we simply note a hyperaemic softening and condition of Osteoporosis. Changes in the head and acetabulum from the abnormal function required of them, produce as we would expect, alterations according to Wolff's Law dependent on this new pathological function (Figs. 314, 315, 316, 317, 318 and 319).



FIG. 317.—X-ray of same, left side. (*Robert Jones.*)

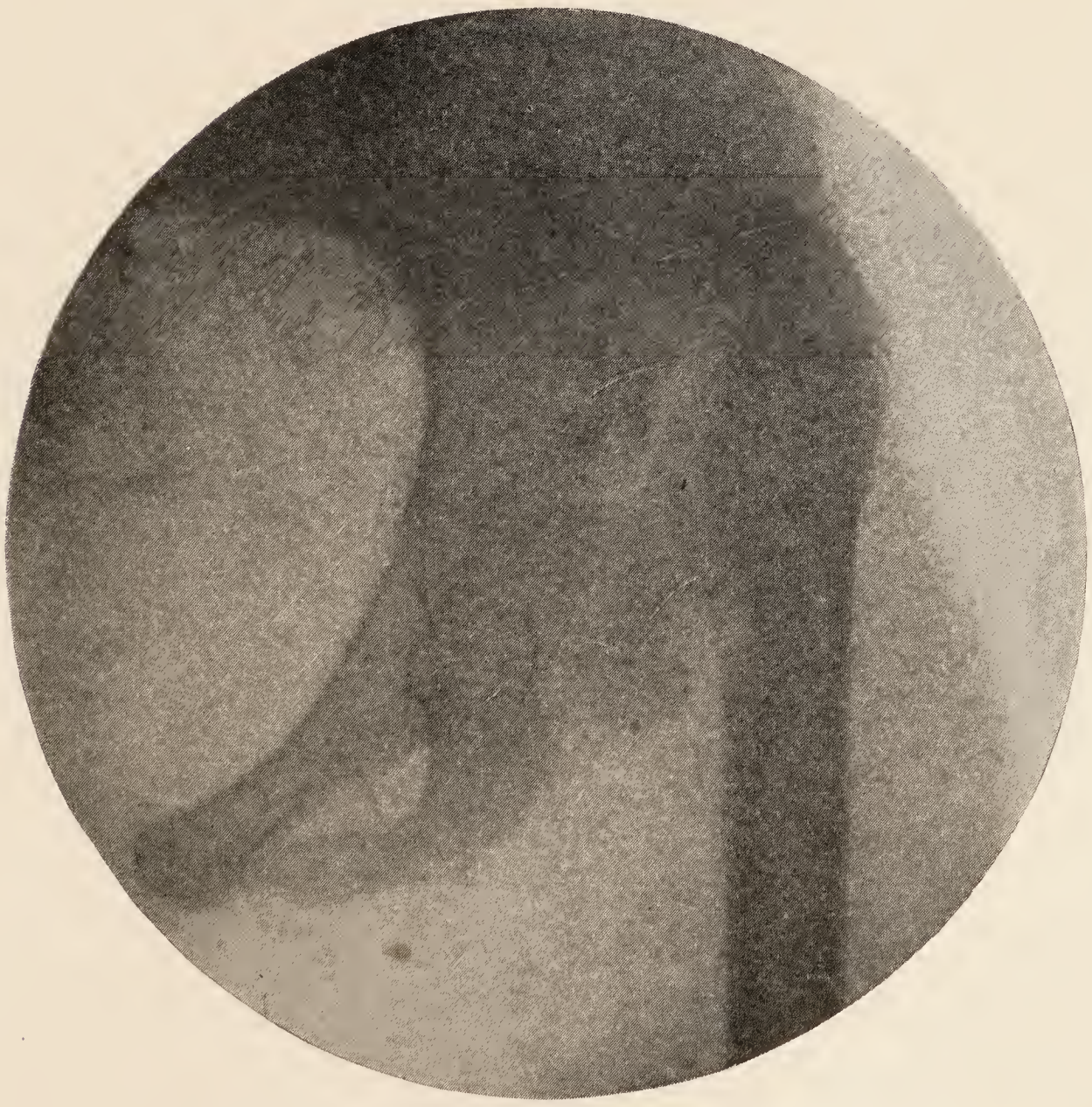


FIG. 318.—X-ray of same, right side. (*Robert Jones.*)

Symptoms.

1. **Onset.**—This condition usually progresses over a period of from two to four years and is gradual in the production of the increasing disability.

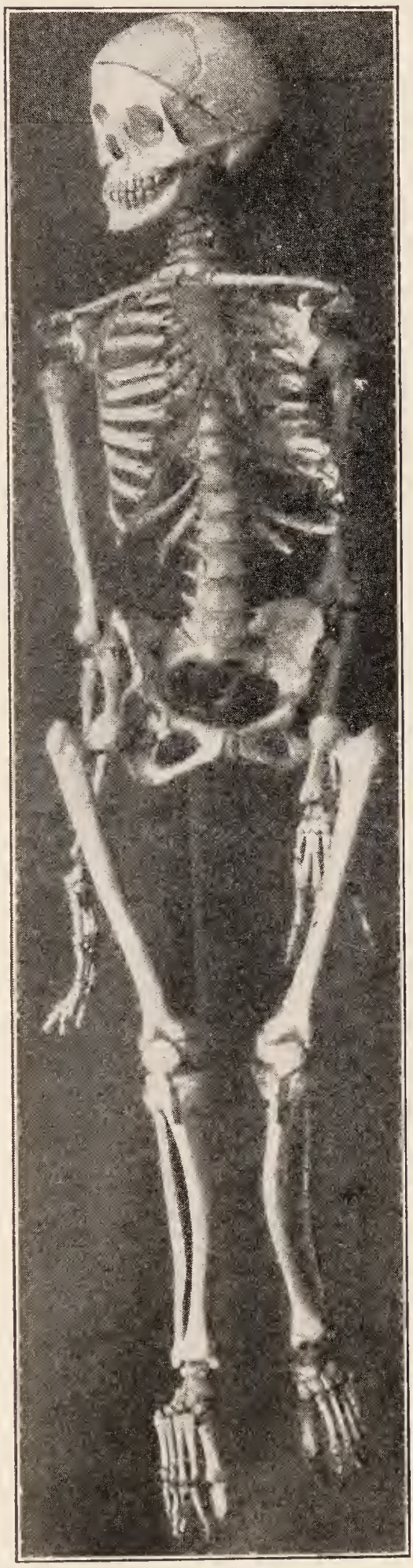


FIG. 319.—Rachitic dwarf. Femora showing coxa vara. (*Wistar Institute of Anatomy.*)

2. **Function.**—Among the chief complaints of these patients are awkwardness, stiffness and weakness. Pain is rarely present, except from over-use and undue strain.

3. **Limp.**—The lameness in these cases suggests that of a man walking with a wooden leg or what we see in the milder cases of ununited fractures of the neck of the femur. At every step the pelvis is lifted unnaturally on the affected side by lumbar muscles.

4. **Muscle Spasm.**—This symptom is not usually present except when associated with the pain of over-use.

5. **Atrophy.**—This is present from non-use or defective use.

6. **Flexion and Adduction.**—In Double Coxa Vara the condition is very similar to that seen in knock-knees, as the trochanters are a greater distance from the mid-line, the bones approach each other from above downward in a more oblique direction and similarly in severe cases, when the legs are flexed, they cross each other from the oblique pull of the psoas magnus muscle. This, of course, procludes several occupations especially those incident to riding horse-back, as abduction of the thighs is not possible.

7. **Lumbar Spine Changes.**—As the diaphysis of the bone is thrown forward by the decreased forward inclination of the neck, the centre of gravity of the body in relation to the legs is thrown further forward. The inclination of the brim of the pelvis is therefore less than 60° and the lumbar spine shows less lordosis than normal and is more flattened. Conversely, in these cases where the angle of the neck shows an inclination greater than 12° with the diaphysis and the diaphysis is thrown further back, lordosis may be increased.

8. **Position of the Trochanter.**—In all cases the trochanter is above Nelaton's Line. This is dependent upon the degree of the deformity. In no instance is there any slipping of the head out of the socket producing what is known as telescoping seen in Congenital Hip Dislocation. In other words, we find a stable joint. The trochanter is always unduly prominent.

9. **Shortening.**—The real shortening measured from the anterior-superior spine to the internal malleolus is usually not more than one inch and is usually less, but the apparent shortening may be two to three inches from the marked adduction caused by the increased pull of the psoas on the trochanter minor and the upward tilting of the pelvis on the affected side. This tilting of the pelvis usually produces a scoliosis in the spine usually with the convexity toward the normal side (Fig. 320).



FIG. 320.—Ninety degree Coxa Vara.

Prognosis.

Untreated, this condition tends to get worse, especially in the growing period and when associated with the softening stage.

Treatment.

In infants and young children this condition is often overlooked. During this period, recumbency and traction in abduction would arrest and possibly correct the bending of the femoral neck. If discovered, this method of treatment should be resorted to, combined with anti-rachitic remedies such as good hygiene, fresh air, cold stimulating or contrast baths, sunshine and cod liver oil.

In adolescents, especially, the cases that show epiphyseal dislocation, forcible manipulation, under an anaesthetic with thorough stretching of the adductors, psoas and other flexors and the application of a plaster spica from the ribs to the tips of the toes with the leg in extreme abduction should be worn for six months or a year.

Frequently the Whitman operation is essential through an incision commencing one inch below the tip of the trochanter major and extending vertically down three or four inches. After retraction of the periosteum and a transverse incision is made in the bone extending three-quarters across it in the region of the trochanter minor and at a point ¾ of an inch above this point, an oblique incision is made to join the first incision near the trochanter minor. Then this cuneiform portion of bone is removed, which at its widest point is ¾ of an inch wide. The remaining portion of bone near the trochanter minor acts as a hinge and on marked abduction a green stick fracture is produced at this hinge and the relation of the neck and head may be restored to normal. If there is a backward inclination of the neck, this can be restored at the same time by giving an internal rotation to the lower fragment while the cast is being applied. The cast or spica applied after open operation should extend from the xiphoid cartilage for lower thoracic fixation to the tips of the toes and should be worn two months, after which a pelvic spica to the knee with a perineal strap through the groin of the unaffected side for fixation and to maintain the abducted position should be worn six months to a year (Fig. 321).

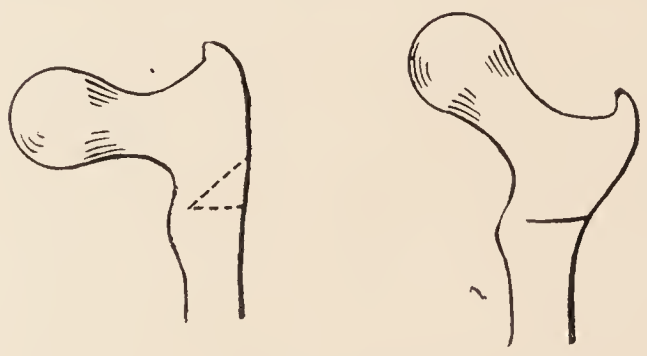


FIG. 321.—Whitman cuneiform osteotomy before and after removal of wedge of bone.

In certain adult cases where the disability is marked, the ordinary Gant Sub-Trochanteric Osteotomy may be done and the leg carried into an abducted position and a spica applied in the usual way with most satisfactory results.

Perthes' Disease.

This disease, first described by Legg[1] as "An Obscure Affection of the Hip Joint," was more fully studied by Perthes[2] and has borne his name since. He called it "Osteochondritis Deformans Juvenilis." Henry Ling Taylor and William Frieder wrote of it as "Quiet Hip Disease," as it had been confused with and treated as Tuberculous Hip Disease previously and the end results were often infinitely better and the duration of the disease shorter than the latter.[3]

Definition.

It is characterized by limp, slight pain, if any, and usually limitation of motion in abduction and outward rotation. There is, as a rule, some muscular atrophy in the thigh muscles near the joint and the trochanter is prominent. It runs its course in a few months or a year then recovers with but little impairment in the joint function provided protective treatment is given early.

[1] Boston Med. and Surg. Jour., Feb. 17, 1910.
[2] Archiv. fur Klinische Chirurgie, 1913, page 779.
[3] Amer. Jour. Ortho. Surg., 1915, vol. xiii, No. 2.

Causes.

It is a disease of childhood seen usually from the fourth to the tenth year (Blanchard) and according to Legg is due to some circulatory disturbance, although he found a septic focus in one of 13 cases.

Trauma may or may not be an etiological factor. Kidner considers it a low grade haematogenous infection and found a cavity containing greyish red material, which yielded on culture the staphylococcus aureus. Roberts has



FIG. 322.—Perthe's Disease. (*Courtesy of Dr. Charles A. Waters, Johns Hopkins Hospital X-Ray Laboratory.*)

found in some of his cases suggestive evidence of congenital syphilis and Freiberg has found it associated with tonsillitis. The true cause is still undetermined.

Frequency.

It constitutes less than 5 per cent. of the cases of Hip Affections seen.

Pathology.

The X-ray gives one the impression of a loss of calcium salts in the epiphysis and subepiphyseal region with loss of the rounded contour of the epiphysis,

so that it is so markedly flattened and laminated as to be mere platelets of bone. Occasionally one sees irregularity in the epiphyseal line, which may suggest a small cavity or cavities from absorption or decalcification. There is no haziness as in tubercular disease. The neck becomes shorter and slightly broader than normal (Fig. 322).

From sections, Perthes showed an extension of cartilage into the normal bone area. In recovery, the softening gives place to eburnation, lime salts are redeposited, but the neck is stunted, the head flattened and takes on the "mush room" shape with a resultant slight limp and shortening of from one to three centimeters, depending on the degree of involvement and time efficient treatment was instituted. Allison attempted to reproduce the disease in rabbits by trauma, but failed.

Symptoms.

As stated above, the limp is the chief symptom and pain is usually only elicited when extreme limits of forced motion are attempted.

Prognosis.

Prognosis is good even without treatment, but necessarily flattening of the head and shortening of the neck as to degree must be lessened by removal of weight-bearing and traction.

Diagnosis.

Diagnosis is made by the mild nature of the symptoms and very characteristic X-ray.

Treatment.

Treatment should be identical with tubercular hip disease at the onset, including recumbency and traction for a month or more followed by the use of crutches, a high shoe on the foot of the well leg, plaster of paris spica or traction splint. The treatment should be guided by X-ray studies from time to time to note the progress towards recovery.

Congenital Hip Dislocation.

Definition.—Children showing this disability, as its name implies, have had it since birth and it occurs usually as an outward, upward and backward dislocation. The forward variety of dislocation is unusual. The capsule of the joint is elongated and constricted and the head of the femur is found at some adjacent place other than in the acetabulum (Figs. 323 and 324).

Frequency.

About 85 per cent. of these cases occur in females and they comprise one or two per cent. of all the orthopaedic cases seen. According to Albee, they are frequent in cases with a family history of alcoholism, especially on the maternal side and also of hereditary syphilis. The occurrence in the author's experience seems more common in children of Scandinavian descent.

History.

Up to 1900 but few treatises had been written upon this affection, which was considered incurable, although in 1847 Pravez of Lyons had probably attained a few cures, which was also accomplished by Paci of Pisa in 1887 by a method very like the method later suggested in 1900 by Lorenz. Dupuytren in 1826, the earliest writer, discussed the gross anatomy of the condition accurately. Hoffa, Lorenz, Bradford and Calot have done much to increase our knowledge of the pathological changes in the component parts of the joint in this condition.



FIG. 323.—Bilateral dislocation of hip. Showing great width of pelvis, prominent trochanters and wide perineum. (*Barton Hopkins.*)



FIG. 324.—Bilateral dislocation of hip. Showing extreme lordosis. (*Barton Hopkins.*)

Pathology.

Hoffa describes four different stages of this dislocation. The first is when the head of the bone is in an outward relation to the acetabulum with its apex opposite the center of the Y-cartilage. The second stage is when the head of the bone is on a level with the anterior inferior-spine. The third stage is when the head is on a line with the anterior-superior spine. The fourth stage is when the head rests on the dorsum of the ilium above and posterior to the anterior-superior spine. These stages probably occur progressively as the child increases in age and weight, as the body is slung to the femur entirely by the capsule of the joint and muscles, as though by a strap ((Figs. 325, 326 and 327).

1. **The Acetabulum.**—In the roentgenogram, one notices at first a shelving off of the upper and outer margin of the acetabulum, which normally has the appearance of a right angle with the lateral surface of the ileum and as this becomes more marked in the later stages, this shelf, against which the head of

the femur normally rests, disappears entirely so that the side of the ileum and the acetabulum becomes practically a straight line. In addition to this, with the non-formation, which is probably congenital, of the cartilaginous rim of the acetabulum and the supporting bone, the floor of the acetabulum becomes much thicker from bone deposit and also fills in with fibrinous tissue and is covered in many cases by the posterior and anterior surface of the capsule, which are apposed and become much elongated. As a result of this tendency, the acetabulum is very shallow and instead of being round in shape, is triangular or ovoid.

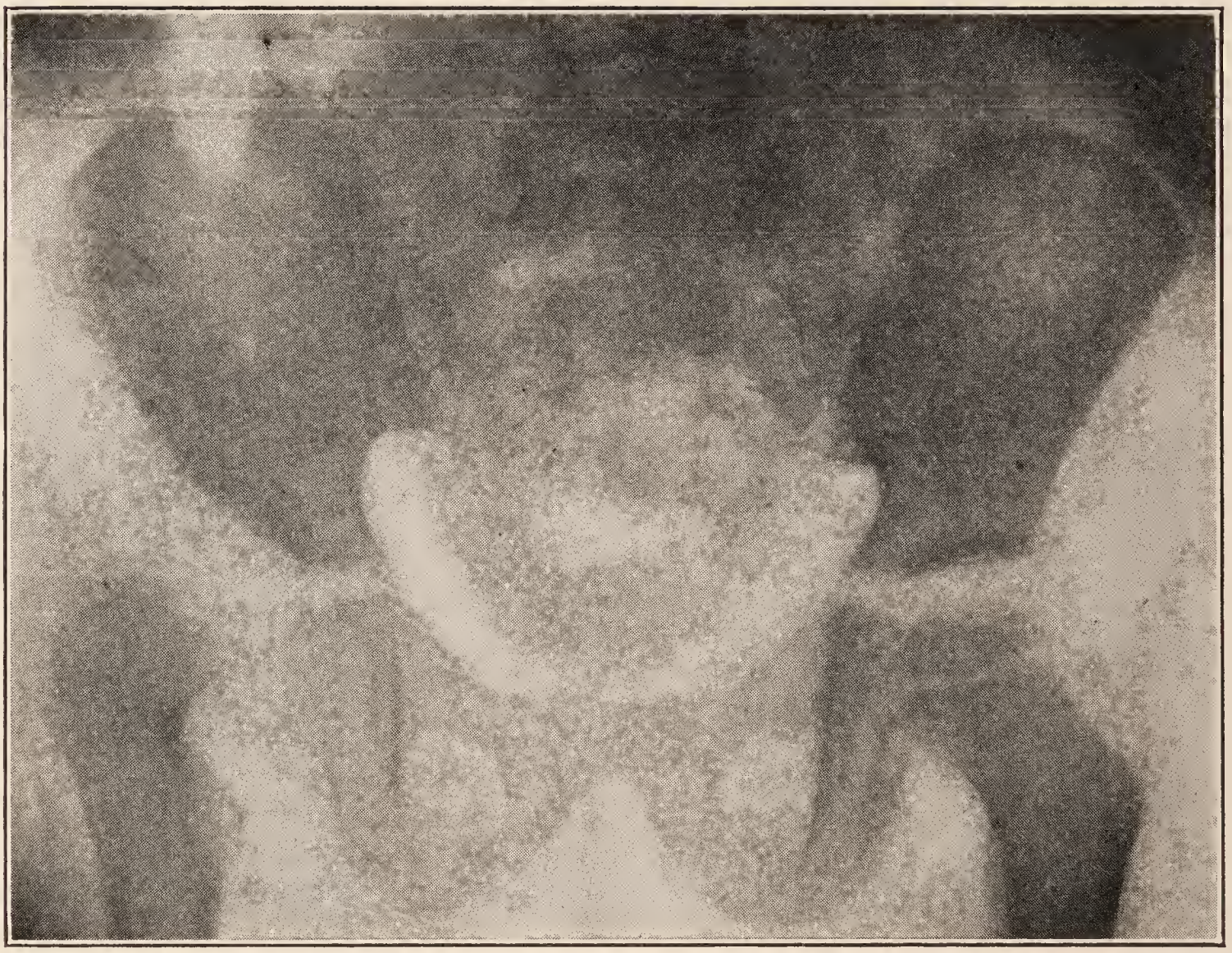


FIG. 325.—First stage of unilateral dislocation.

2. **The Head and Neck of the Femur.**—In nearly all of these cases changes are noted not only in the hemisperical shape of the head, which has become conical, pointed or worn away by attrition on the upper and posterior aspects, but may be flattened, broadened outward as the head of a hammer, whose striking surface becomes spread out and turned up around the rest of the head from use. In addition to this, the neck of the femur assumes usually more of a coxa vara shape; namely, less than 125° with the shaft and is shorter than normal and is usually deflected forward by pressure or twist in the shaft of the bone, so that the angle in relation to the transverse diameter of the condyles is more than 12° in some instances. We may have a coxa valga or entire absorption of the neck of the bone, so that the articulating surface may be on the upper end of the shaft close to the trochanter. Still other appearances, in rare instances, may be mushroom-like, or, as Lorenz describes it, like the buffer of a railroad car. These deflections of the head and neck have important



FIG. 326.—Second stage of bilateral dislocation. (*Young.*)

bearing on the position in which the limb is to be placed after reduction. Thus, for example, if we have a forward deflected neck of 90°, when the head is placed in the acetabulum, the patella, instead of pointing forward, must be rotated inward, so that it points towards the other leg. This final position, therefore, must be a law unto itself, depending upon the pathological changes that have occurred.

3. **The Capsule.**—As the capsule is the chief supporting structure of the joint after dislocation, it not only undergoes thickening but elongation, covers the acetabulum and assumes an hour-glass shape, one portion surrounding the acetabulum and the other the head of the bone with a constriction between,

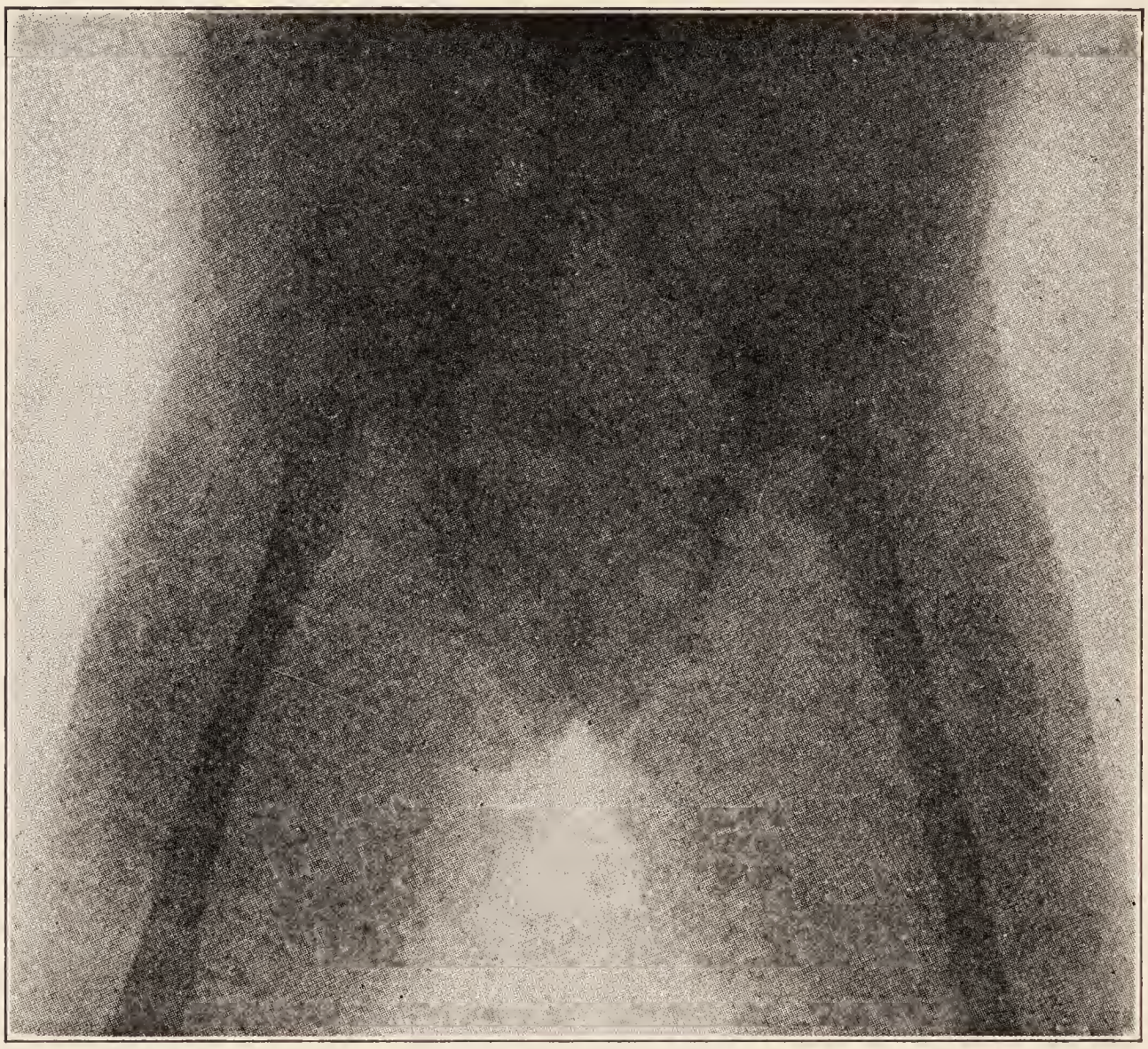


FIG. 327.—Third stage of bilateral dislocation. (*Augustus Wilson.*)

which is largely brought about by pressure from the psoas muscle, which now passes obliquely outward over it to be inserted into the trochanter minor. The acetabulum is lined with synovial membrane and still contains synovial fluid and rudiments of the attenuated ligamentum teres, if this has not been entirely absorbed. It is stated by some writers that the ligamentum teres is absorbed in the fourth year. Others claim that it is present in unilateral congenital dislocation, but absent in bi-lateral. In order to bear the weight of the body, the capsule is hypertrophied on its lower and posterior aspects. The constriction in the capsule is one of the chief difficulties to be overcome in getting the head of the bone actually in contact with the acetabulum. The head must go through the constriction. If this is not done, it can be readily understood,

a fold of this interposing structure will cause the head readily to slip out of the socket again, if not mechanically held in position by a cast.

4. **The Muscles.**—It can easily be seen that with the ascent of the head of the bone on the ileum with the shortening of the limb, which is occasioned thereby, that the muscles, which extend between the knee and the pelvis are proportionately shortened and other muscles that extend between the pelvis and the trochanter, which now projects conspicuously outward, are lengthened. Hoffa, Lorenz and others have divided these muscles for purposes of description into three groups as follows (Fig. 328):

(*a*) *Pelvi-crural*, namely, the hamstrings, the gracilis, the pelvic, head of the rectus femoris, sartorius, tensor vaginae femoris and the group of the adductors with the exception of the adductor brevis and minimus are shortened.

(*b*) *Pelvi-trochanteric group*, consisting of the glutii, the obturators, the quadratus femoris and the psoas, are lengthened and changed in their direction and function.

(*c*) *Pelvi-femoral group*, consisting of those portions of the adductors, which do not extend to the knee are shortened.

It can readily be understood that the muscular shortening must be overcome either by knife, stretching or tearing in order to get the head back down in its porper location.

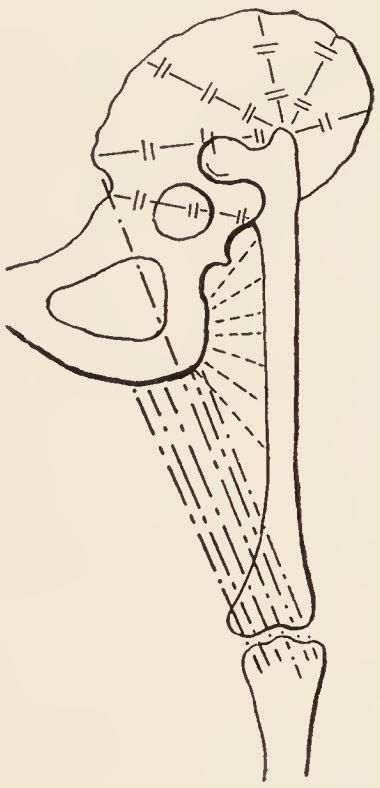


FIG. 328.—Diagrammatic representation of shortening and lengthening and change of direction of muscles in congenital hip dislocation. — . — . — . — Pelvi-crural. – – – – –, Pelvic-femoral. —?—?—?—?—, Pelvi-trochanteric.

5. **The Side of the Ileum.**—Hoffa has described what he calls a "glide-furrow," indicating the course that the head of the bone has followed after it leaves the acetabulum. Lorenz has spoken of this furrow as "false acetabula," but they are simply depressions in the bone covered by periosteum without cartilage, representing transitional "steps" of resting places for the head of the bone in its progressive ascent upward. On manipulation these "steps" can sometimes be detected by the sense of touch.

6. **The Inclination of the Pelvis.**—Normally, the forward inclination of the brim of the pelvis is 60° with the horizon. With the backward dislocation of the femur, the center of gravity is thrown forward and this inclination may be very much increased producing almost a vertical relation of the crest of the ileum with the horizontal plane upon which the patient stands and a corresponding tilting forward of the sacrum, which may be abnormally and markedly concave forward. This increased lordosis is much more noticeable in bilateral cases and is very characteristic of this affection. Unlike Coxa Vara, with its stable joint, the pelvis sags down on the affected side. If the weight is borne on the affected leg, pressure is brought to bear more on the ileum on that side and the brim of the pelvis is constricted transversely, whereas the ischia are further apart, making the transverse diameter of the outlet greater than normal. Scoliosis usually takes place toward the affected side. In bilateral cases, of course, scoliosis is not usually present.

Etiology.

Defective development of the whole or only the posterior margin of the acetabulum may be chief factors in the production of Congenital Hip Dislocation. Or excessive stretching or congenital elongations of the capsule may be causative. The disparity in the width of the pelvis and differing obliquely of the femora in the male and female infant does not appear as in the adult, so that these suggestions or theories as to the causation do not explain the preponderance of females over males with this affection.

Obstetrical injury does not explain it either, as the usual number of these cases have histories of occipital presentation, as seen in normal children, and foot, leg or breech presentations are the exceptions. Crowding in utero is purely a theoretical hypothesis with thighs flexed and the flexor muscles during development undergoing adaptive shortening, so that when extended these act as fulcra and the heads of the femora are thrown out of the acetabula after birth, but this does not explain its greater frequency in the female.

Thus the true cause is as yet unknown. However, if a case could be followed roentgenologically from birth, one would probably note a relaxed joint with the head laterally displaced in relation to the acetabulum, at a distance greater than normal and as the child matures and her joint is subjected to weight-bearing, the upward and backward dislocation of a greater and greater degree occurs, together with attrition of the postero-superior margin of the acetabulum and distorting stresses from abnormal muscular pull on pelvic development.

Symptoms.

1. **Snapping Hip.**—The displacement or dislocation is not recognized by the mother or nurse until the child begins to walk, but there may be evidences of relaxation, giving rise to "clicking," "snapping" or other peculiar sounds at the hip joint as the child is bathed or manipulated in changing the diaper, when the legs are flexed and adducted and then extended.

2. **Prominent Trochanter.**—An undue "prominence" or "swelling," "tumor" or "lump" may be described to the physician as existing in the region of the femoral head or trochanter, especially the latter.

3. **Limp.**—The older the child, the more pronounced the limp is as a rule, which is described by the parent to have gotten progressively worse since the days of first walking. This is explained by the child's increase in weight. When the dislocation is unilateral and of the second, third or fourth degree, there is an extensive excursion of the head from near the aectabulum to the remote region on the ilium by the alternate weight-bearing and contractility of the periarticular muscles in taking a step. This is known as "telescoping" being compared to the sliding of one tube within the other and out again in a telescope. It may be elicited in the recumbent patient by pushing the thigh up and down. This limp gives the appearance in unilateral cases of one stepping down a step. The pelvis sags downward and forward on the affected side at each step. In bilateral cases a waddle or roll like a duck or sailor with abnormal sway-back or lordosis, makes the diagnosis, when once understood, clear at a glance. It suggests a bow-legged waddle, but on inspection the bowed legs are absent. The pelvis sags downward and forward alternately on the two sides supported by its capsular slings.

4. **Shortening.**—This varies with age from ½ an inch to 2 inches or more and this especially in older cases may be both an apparent and real shortening from the abnormal pull of the psoas and the flexors arising from the anterior-superior spines on the outwardly displaced trochanters. We may find a permanent flexion or "position of flexion" from the adaptive shortening of these pelvi-trochanteric or pelvi-femoral structures. In bilateral cases the shortening is about equal on the two sides.

5. **Abnormal Mobility.**—One is struck at once with the abnormal range of motion, especially in young children with this affection, when on the examining table as regards rotation, for the head of the bone can be thrown forward and easily palpated under the skin or superficial muscular structures, as well as "telescoping" the leg, when grasped and thrust up and down. In older and extreme cases, where the head, neck and trochanter have ascended high up and are snugly held by the glutei and tightly and adaptively shortened adductors, abduction is much restricted.

6. **The Trochanter Major.**—This is found above the Roser-Nelaton Line and the base of Bryant's Triangle is less than normal. The Hypothenuse of Bryant's Triangle in forward twisted necks is unduly long also. The trochanter is abnormally prominent as has been stated and young females with bilateral dislocation, the contour of the hips suggests the appearance of the older mature woman.

7. **Trendelenburg's Sign.**—The tone of the glutei is lessened and the buttock flattened, partly by the filling in of the post-trochanteric fossa with the bone itself, but largely by the obliquely upward and outward slant of the muscles, so that the gluteal fold, when the weight is borne on the affected leg, is directed upward and outward instead as is normal in the individual, being horizontal or even upward and inward. This is known as "Trendelenburg's Sign."

8. **The Perineum.**—Owing to the narrowing, from side to side, of the brim of the pelvis and spreading apart of the ischia and widening the outlet, as well as the wider separation of the femora incident to the displacement to a wider portion of the pelvis, the perineum is much wider than normal. At a glance, one notices that the adductors and skin do not touch at the perineum as in the normal standing individual, but the perineal space is much widened dependent on the degree of the dislocation.

9. **Lordosis and Scoliosis.**—Lordosis is present in both the unilateral and bilateral cases, but much more marked in severe cases of the latter, as the centre of gravity of the trunk is thrown forward. Scoliosis is more noticed in the unilateral cases, of course, and depends on its direction as to whether the pelvis is tilted up or down on the affected side. If the affected leg is much *adducted* and the deformity extreme, the Scoliosis will be convex toward the sound side as the pelvis is tilted upward on the affected side.

10. **Pain.**—Pain is a negligible symptom in early cases and is rare in advanced cases, but the older cases are apt to be subjected to strains or sprains of the ligaments at the hip from accidents or twists to the insecure joint, which are only to be relieved by rest, recumbency, immobilization and wet compresses. In all advanced cases one notices a lack of endurance, ready fatigue and labored progression, which amounts to discomfort.

Diagnosis.

No serious difficulty should be experienced in making a diagnosis of Congenital Hip Dislocation at a glance, when one is familiar with the pathology and symptoms of this condition. Especially suggestive are the history, limp, lordosis, prominent trochanter, telescoping and wide perineum. In all cases the X-ray readily establishes the rational impression or tentative diagnosis conclusive for or against a positive one. Conditions may arise from Anterior Poliomyelitis with paralysis of the glutei and over action of the adductors producing a paralytic dislocation backward and upward, which may cause confusion. Or the destruction of the head or neck or capsule following an Acute Infectious Arthritis in infancy resulting when healed in an insecure or unstable dislocated joint, may lead to an erroneous diagnosis on inspection, but lacking the congenital factor, readily clear up when the history of the etiological disease is obtained and the X-ray shows the destruction or bone atrophy.

Coxalgia shows, on the other hand, undue fixation and other characteristic symptoms of tubercular bone disease.

In Coxa Vara, the stiff wooden legged gait and absence of telescoping are noted and radiograms show the head within the acetabulum. Abduction is limited from the start and only in the fourth stage of Congenital Hip Dislocation.

The lordosis of Lumbar Pott's with a history of spinal stiffness, pain, night cries, etc., coming on usually after infancy and of Muscular Dystrophy or Pseudo-Muscular Hypertrophy, as it is preferably called, have a shuffling gait somewhat suggestive of Congenital Hip Dislocation, but of a milder degree and the progressive loss of power in the latter case, dating usually from near the second decade of life, renders confusion unlikely.

Distinction in rare instances must be made of disabilities of the hip due to Supracotyloid Displacements or Anterior Dislocation where the femoral head, while not in the acetabulum, is held fairly securely by the muscles arising from the anterior-superior spine. Where absolute reduction of the backward and upward or common variety of Congenital Hip Dislocation fails, often the end result is an anterior dislocation or, as it is often called, an Anterior Transposition. In either this or the Congenital Supracotyloid or Anterior Dislocation, the disability is much less, the pseudo-joint more stable and the centre of gravity falls near its proper position and no unsightly lordosis occurs, in fact, the lumbar spine may be straighter than normal.

Prognosis.

It can readily be understood that in the ordinary variety of Congenital Hip Dislocation untreated the outlook is bad, for a progressively increasing disability up to the limits of the glutei, with strains, instability, fatigue and lack of endurance and agility in prospect.

Owing to the large number and size of the shortened muscles surrounding the hip joint, these in older children offer a serious obstacle to reduction and the age limit to successful reduction in unilateral cases is usually placed at eight years and the bilateral at six years, but successful and skilled operators have exceeded this age limit. In older cases often one must be content with what Lorenz calls "apposition" or Anterior Transposition as we understand

it. Undue force is naturally unwarranted which produces serious tearing of resisting soft parts or bone fracture in efforts at reduction in older cases and deaths. Nerve- and arterial-tearing, fracture of the femoral shaft and neck and pelvic fracture have been recorded.

The crux of cure in this affection is to get the case young and the difficulties are appreciably lessened and prognosis more favorable. All, however, are liable to slip out after replacement owing to the relaxed capsule and possible redundant or folded-in capsule or ligamentum teres, therefore, the surgeon should be *most cautious* in discontinuing fixation too soon or claiming or *promising permanent cure* in any given case.

Treatment.

After the description given by Dupuytren in 1826 and his holding out but little hope of cure, and but slight expectation of bettering the condition, various surgeons continued efforts to ameliorate the condition. The first of these efforts consisted of apparatus designed to prevent the upward slipping of the head of the femur on the sides of the ileum. One of the simplest of these to be used on inoperable cases is described by Hoffa and consists of a leather pelvic belt on the side of which encircling the trochanter is a padded horse-shoe shaped piece of steel. This belt is kept in place by perineal straps. Schede and Lorenz describe corsets of celluloid, plaster or leather, which extend well down to encircle the uprising trochanter in an effort to prevent further luxation and have perineal straps. Von Volkmann used traction at night and then supplied the patient with a steel supporting brace attached to the shoe with strong perineal resistance and a waist band or attached to a corset which would maintain the limb in a slightly abducted position and at the same time prevent further up riding of the femur. Von Lannelongue suggested what he called the "méthod schlérogene" or a method of injecting counter irritants into the capsule. This was also tried by Lafond, Duval and Humbert and Jacquier with the idea of producing scar tissue and thus prevent further stretching of the capsule. Following these efforts, which were not very productive, Pravez in 1847 used a preliminary traction of from four to six months followed by manual manipulation chiefly in abduction, in an effort to restore the head to its proper position. These cases he kept under observation for two years and met with some success. The next writer of note, and he might be called as the real father of manipulative reduction and cure of these cases, is Paci of Pisa, who, in 1887 presented his method, which, with slight modifications, is the one we use today, but it is chiefly to Lorenz, who made certain valuable modifications that we are indebted for its introduction into America.

Different observers since that time have deemed preliminary traction or operative division of the adductors and the flexors of the leg arising from the anterior-superior spines essential before manipulative reduction is tried, in order to overcome the adaptive shortening, which exists in the muscles in all of these cases. For this purpose, Von Eschbaum devised an apparatus to be used with or without an anaesthetic consisting of a leather pelvic resistance strap on a stand, which consisted of a pelvic crutch, thoracic support and pulley arrangements on the ends of a V-piece, the apex of which began at the pelvic

support. The arms of this V could be separated to any desired angle affording a means of increasing the abducted position. By means of this he got quite extreme lengthening of the shortened muscles.

The Lorenz Operation.

Next, chronologically, we should consider the Lorenz operation. Lorenz recommends folding a sheet and then rolling it so that it assumes about the size of a bread rolling pin. After the child is profoundly anaesthesized, this rolled sheet is placed under the pelvis in such a way that the affected leg projects over the pad and does not interfere with hyper-abduction in the thigh, into a plane posterior to the pelvis. For this operation, Lorenz recommends the



FIG. 329.—Lorenz operation—First step. Leg flexed 90 degrees. Thigh flexed and abducted 90 degrees. Kneading and breaking down the adductor ridge.

ordinary deal table, instead of an operating table, as the average operating table is too high.

First Step.—The leg is flexed on the thigh to 90° and the thigh flexed and abducted as near 90° as the adductors permit. Resistance to this is overcome by kneading the "adductor ridge" and breaking it down with the hyperthena eminence of the operator's right hand, using it in a sawing manner and at the same time extending the knee backward and rotating the thigh outward. In order that this may be accomplished, the assistant presses down upon the anterior-superior spine of the opposite leg and thigh, to hold the pelvis steady. When this adductor ridge is obliterated and the flexed and abducted thigh can be so hyper-abducted that the knee lies in a plane posterior to that of the pelvis, it is deemed that sufficient stretching of the abductors has been obtained.

Second Step.—In order to stretch the hamstrings, the thigh is fully flexed so that the knee touches the ribs and the leg is then extended on the thigh until

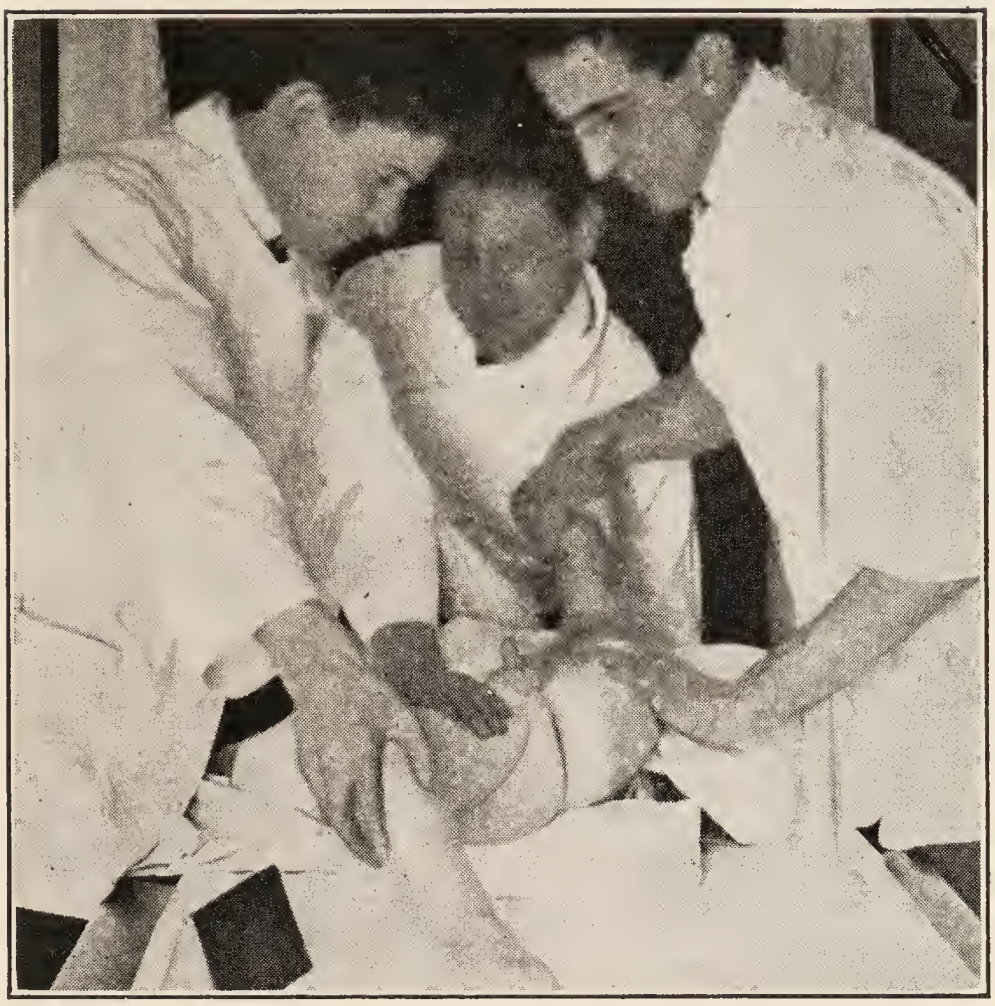


FIG. 330.—Lorenz operation—second step. Stretching the hamstrings by carrying foot to the ear. Rolled sheet under pelvis in first and second steps.



FIG. 331.—Lorenz operation—third step. Child lying on face. Stretching the anterior group of thigh muscles. Heel against buttock, pelvis held down and knee raised.

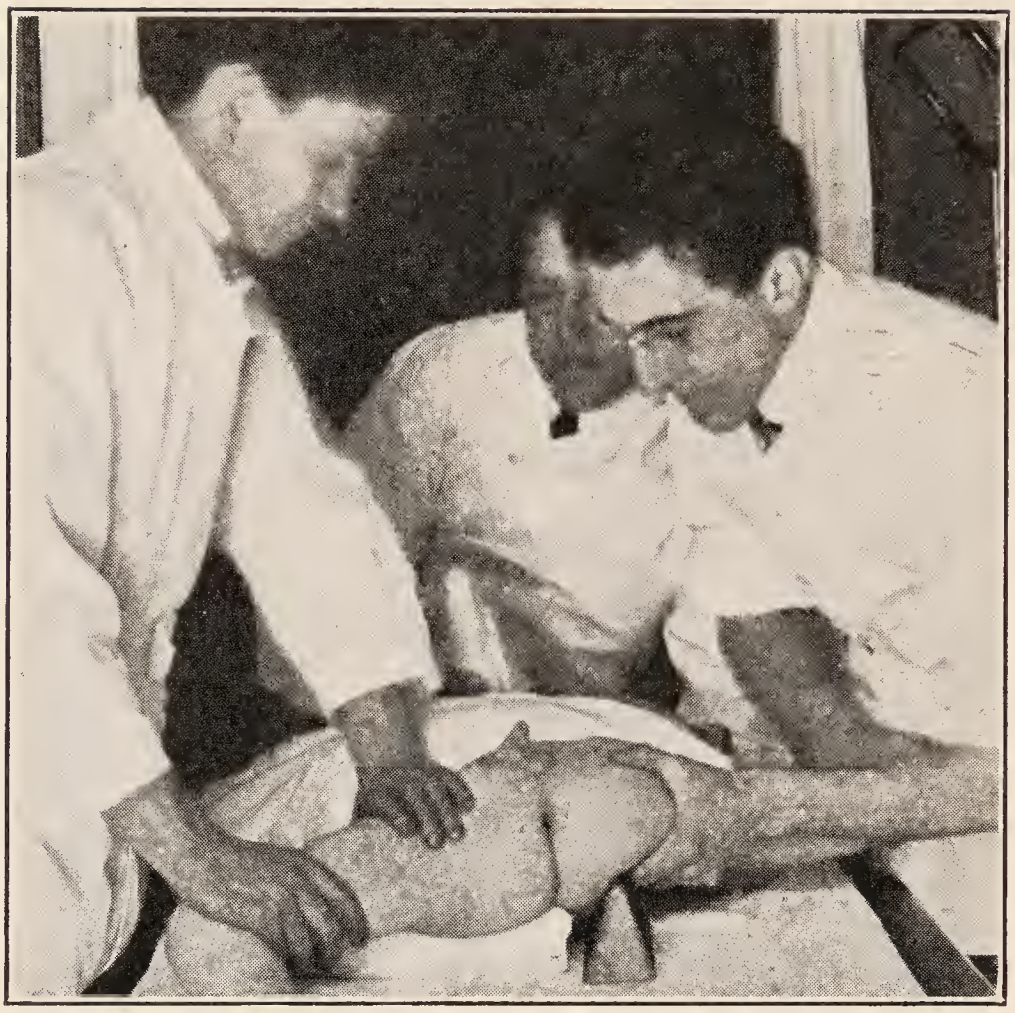


FIG. 332.—Lorenz operation—fifth step. "Reposition." After intermittent traction on the leg (Step 4) to elongate it and bring head down to acetabulum, step one is repeated with addition of wedge under the trochanter to force head forward.

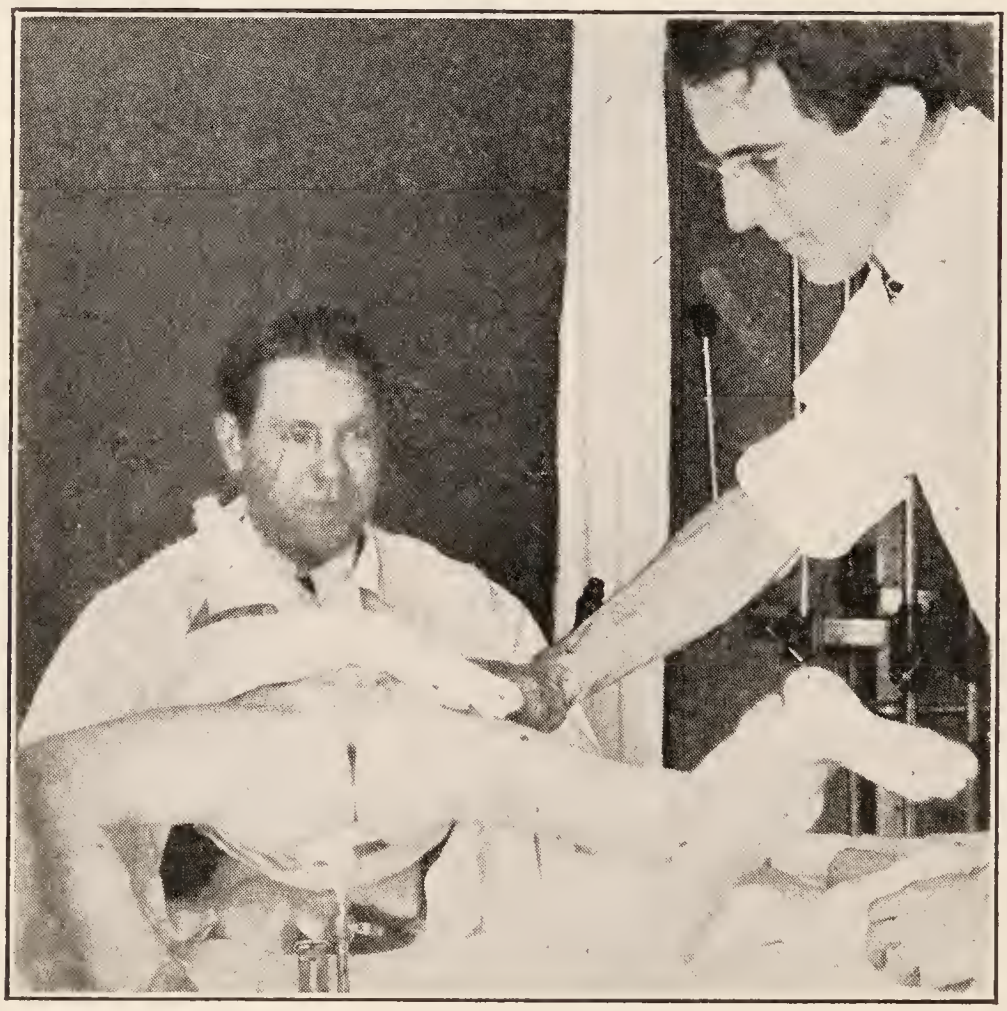


FIG. 333.—Lorenz operation—after step five, "Reposition," when the femoral head is forced into the acetabulum again and again, the child is placed on elevated spica stand prior to the application of fixed dressing to maintain reduction. Cotton foundation for cast being applied.

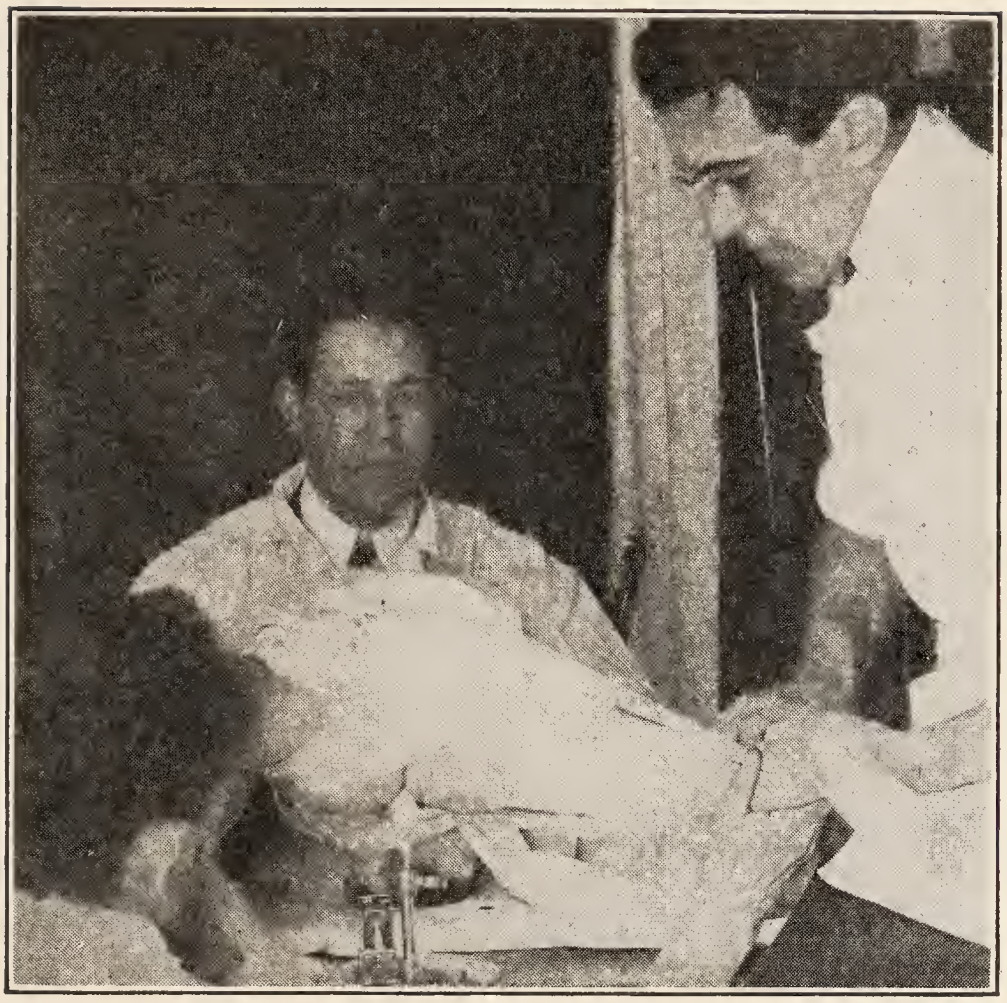


FIG. 334.—Lorenz operation—application of bandages showing direction of turns of muslin bandages prior to the application of plaster of paris to secure "frog position."

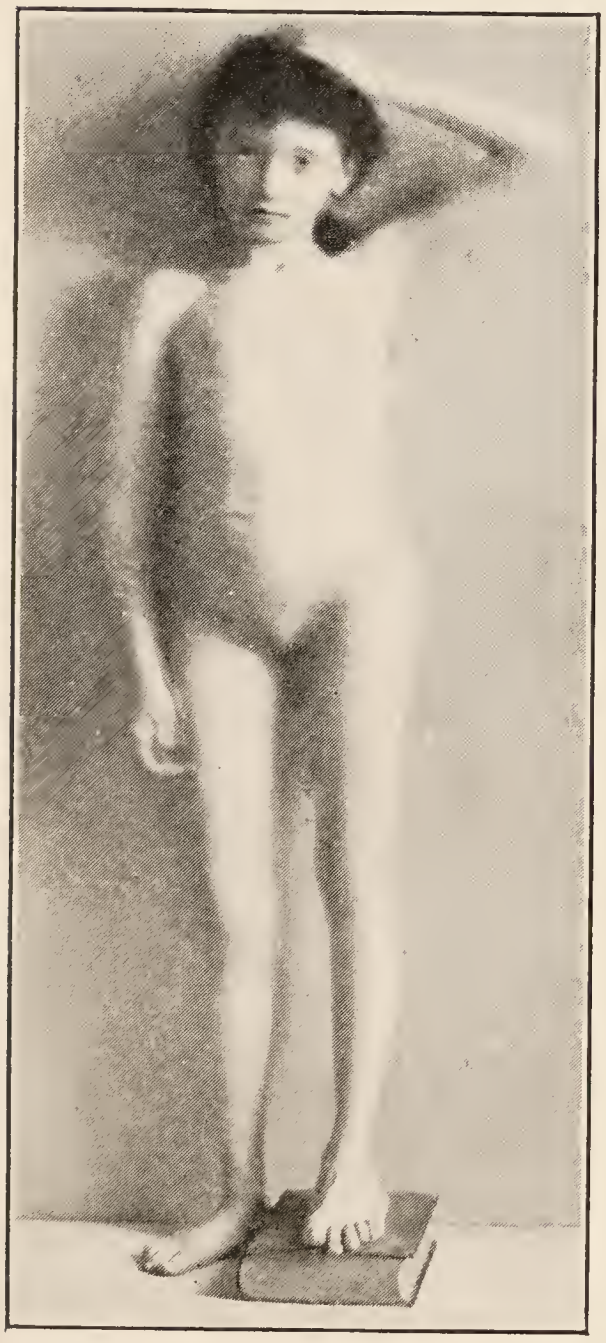


FIG. 335.—Left congenital hip dislocation before operation. Trochanter 2¾ inches above Nélaton's Line.



FIG. 336.—Same case, showing shape of plaster cast and high shoe after reposition.

the foot comes in contact with the ear. The leg, in accomplishing this stretching of the hamstrings, is extended intermittently, just as one would work a pump handle (Figs. 329, 330 and 331).

Third Step.—The child is turned upon its face. The leg is fully flexed so that the heel comes in contact with the buttock and the thigh is then carried forcibly backward, pressure being made on the sacrum by the assistant and operator. In this way the anterior thigh muscles arising from the anterior-superior spines are forcibly stretched.

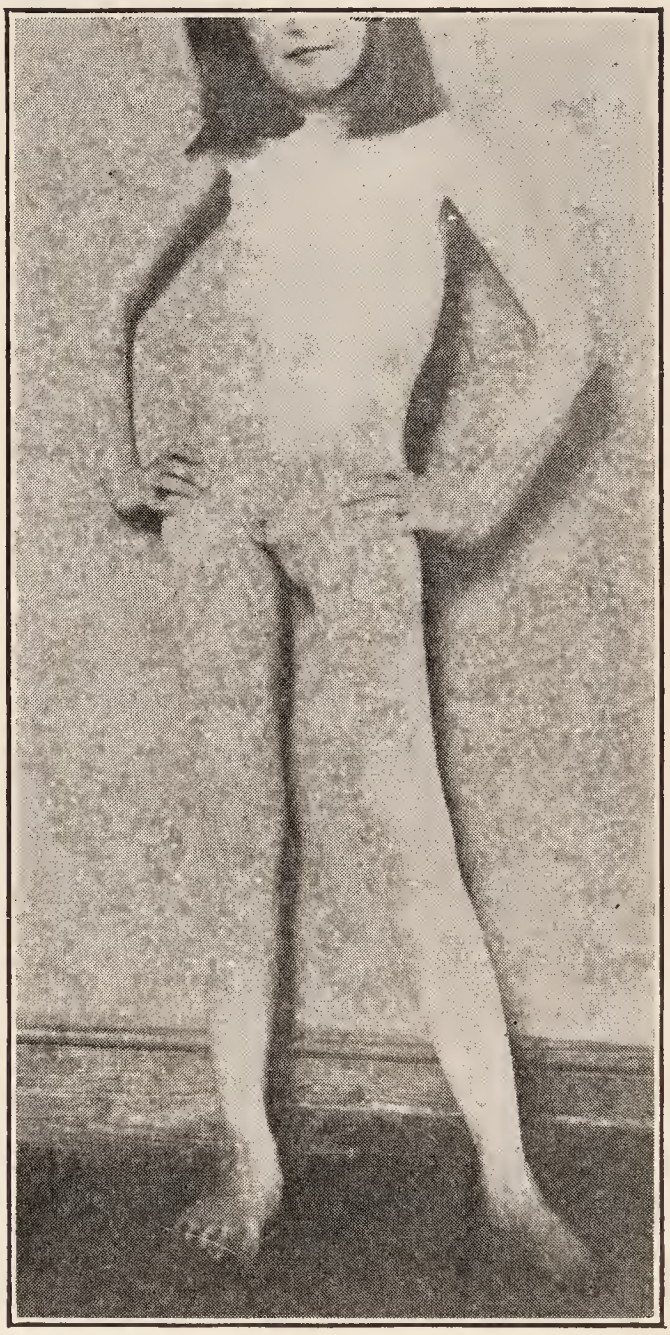


FIG. 337.—Same case cured with abduction and apparent elongation of left leg, which was adducted and shortened as shown in Fig. 335.

Fourth Step.—If at this time the operator feels that the head of the femur has not been brought sufficiently low down to enable him to get the head in the acetabulum, the child is again turned on its back and a sheet is placed through the perineum of the sound side and carried up around the corner of the table, on that side and knotted. The operator and his assistant should then firmly grasp the patient's affected leg at the knee and ankle and synchronously make traction on the leg pulling it down as far as possible (Figs. 332, 333 and 334).

Fifth Step.—This Lorenz calls "Reposition" and utilizes a wooden wedge about three or four inches wide at its base as a fulcrum. The apex is somewhat rounded and covered with leather. This wedge is placed behind the trochanter and the leg is carried into extreme flexion, outward rotation and

hyper-abduction. The wedge thus acts as a fulcrum in order to enable the operator by grasping the thigh as a lever to force the head forward over the posterior rim of the acetabulum. At this time the head of the femur is felt to pop in place, which is sometimes even audible to bystanders. Prior to "Reposition" the leg is flexed on the thigh, being held by the tight hamstrings. When, however, the head goes into the socket, these are relaxed and it is found that the leg can be extended on the thigh without difficulty. This "Reposition" should be done again and again in order to stretch the contraction in the capsule and



FIG. 338.—Replacement of one hip in double dislocation with femur still at 90 degrees.

assure so far as possible the actual passage of the head through its contraction so that we definitely have bone contacting with bone and no in-folded capsule interposed between, which would surely lead to redislocation. The operator then determines in what position stability is assured and is readily found that a certain point in adduction makes the head of the bone slip out again and the leg is to be abducted short of this point. Also certain degrees of extension of the leg on the body or rotation inward or *outward* similarly produces redislocation, therefore, it is desired to place the leg in such a position that redislocation will not occur and at the same time that it is not more extreme than it need be. When a desired position has been reached the pelvis and leg are held while a pelvic support is placed under the pelvis and a thoracic support under the back. Glazed cotton is then wrapped around the foot, leg, thigh and pelvis and a

spica is applied from the knee upward taking in the pelvis. This cast is then worn for from 4 to 12 months, depending upon the stability of the joint and depth of the acetabulum. Sometimes it is possible to lessen this abnormal flexed and abducted position of the leg to a certain extent and after two or three months bringing the leg nearer to a normal position without redislocation. Owing to the flexed and abducted position, there is quite an appreciable shortening and Lorenz believes that weight-bearing is the easiest possible way to deepen the acetabulum by forcible contact of the head, so that he places upon the foot of the affected leg a cork sole from three to five inches high and encourages the child to walk (Figs. 335, 336, 337, 338 and 339).

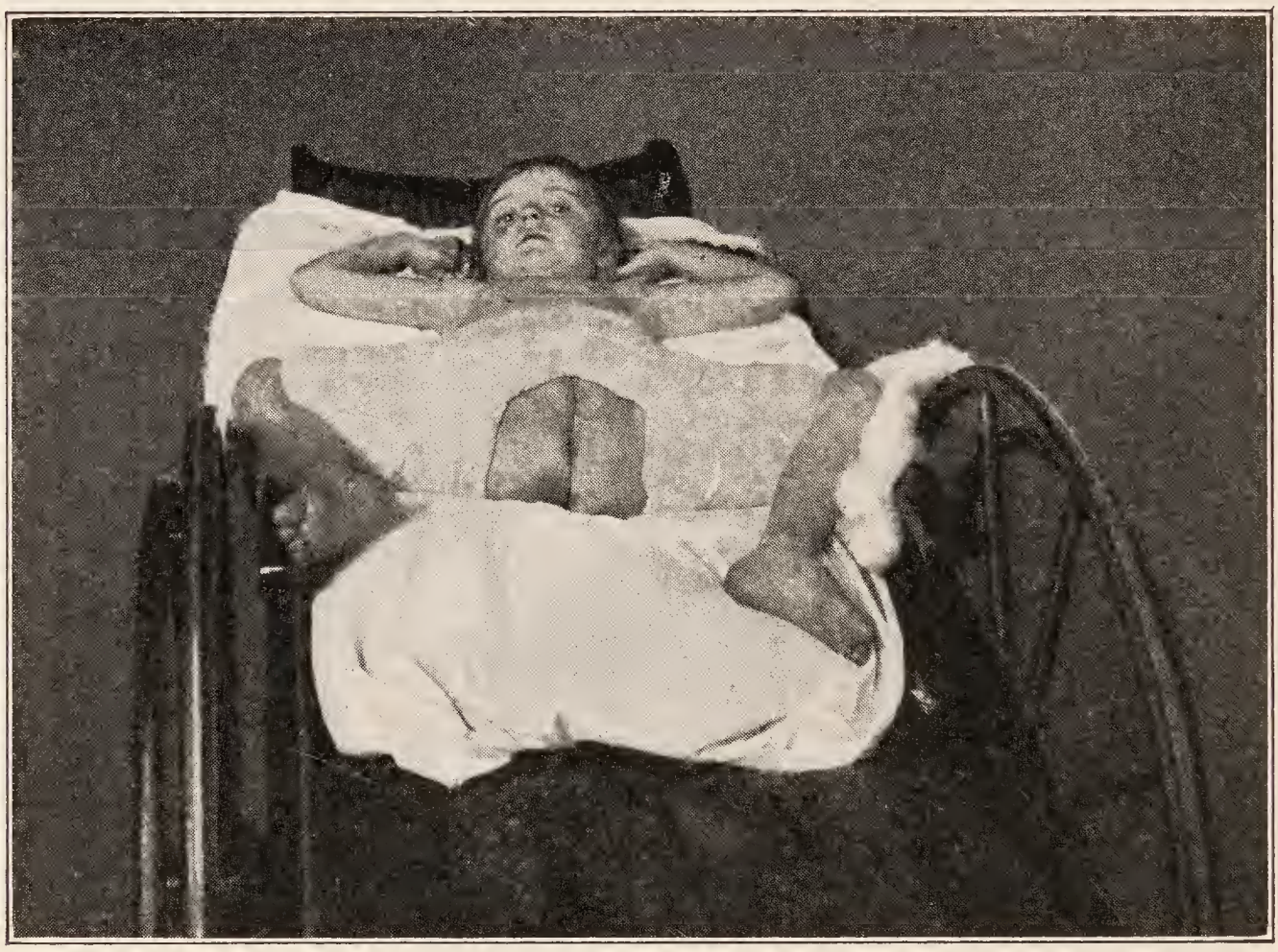


FIG. 339.—Patient with double spica, "Frog Position." (*Augustus Wilson.*)

The Calot Operation.[1]

In certain instances the outward rotated position in Lorenz procedure will place the trochanter and not the femoral head in the acetabulum. Calot gives the following as his manoeuvers:

First Manoeuver.—Flexion of the thigh to an angle of 90° and direct traction on the flexed knee without abduction, adduction or rotation.

(*a*) The operator makes traction on the knee with one hand and with the other one presses the head inwards to assist reduction.

(*b*) This manoeuver is made by two persons, one pulling on the knee and the other pressing directly on the head of the femur. Persist for one, two or three minutes, until, under your fingers, you feel the head disappear all at once into the parts beneath with a more or less distinct click; it is reduced.

This first manoeuver nearly always succeeds in quite small children. If not (after three or four minutes of fruitless efforts) one passes on to the following manoeuver.

[1] Indispensable Orthopaedics; Cabot. Sixth Edition, Vol. ii, p. 729.

Second Manoeuver.—Reduction in abduction of the thigh at an angle of 90° (without rotation or with insignificant rotation).

One commences by flexing the thigh to an angle of 90° and then carries it into abduction with one hand, while the other hand presses from below upwards upon the head. One increases the abduction up to a right angle until the reduction is effected. One can perform this manoeuver alone or better still with an assistant, one effecting the abduction of the knee and the other making direct pressure upon the head of the femur from below upward.

If this manoeuver, repeated five or six times during three, four or five minutes, does not succeed, carry out the following, with which you will always succeed.

Third Manoeuver.—Reduction with the thigh in adduction and internal rotation of 90°.

This manoeuver is almost the reverse of the preceding one. The child being laid on the sound side, and the pelvis supported thus "edgewise" by two firm hands, one assistant takes the affected thigh, flexes it at a right angle, then carries it, no longer outwards but inwards in forced adduction, adding to it an internal rotation of 90° and pulls on the knee as much as he is able. You yourself, then, placing your two thumbs on the head of the femur, easily perceptible above, push it with all your strength towards the acetabulum.

It will make its way there, generally without any sound, with this manoeuver. When you have felt it sink under your thumbs and disappear into the deeper parts, you request your assistant, who is holding the thigh in adduction, to bring it into abduction little by little, pulling it always towards him, until it has reached an abduction of 90°, that is, to the position of the second manoeuver.

This transposition of the thigh from within outwards, made while you maintain the head firmly flattened against the acetabulum with your thumbs, achieves and completes the reduction.

First Position, First Plaster.—One does not always maintain in the position where one has reduced the luxation; the position after reduction may vary according to the case, while the position of maintenance remains always the same.

Here is the position which you will give to the thigh in the first plaster; immediately after the reduction. I recommend 70, 70 and 0, which means: 70° of flexion, 70° of abduction and 0° of rotation.

That is the position by choice for the thigh, the best position for the excavation of the acetabulum. As to the leg itself, it is flexed at an angle of 90° to 100° on the thigh.

Second Position, Second Spica.—The alteration of position is made without anaesthetic. But, however, if the child is too nervous employ ether. In the technique of alteration from the first position to the second, it is a question of putting the thigh first, in extension in the plane of the table, or almost so (slight flexion of 15°) second, in abduction of from 30° to 35°; and third, above all, in internal rotation of from 55° to 60°.

This second position, then, may be formulated in this way: 15; 30; 60; namely, 15° of flexion, 30° of abduction, 60° of internal rotation.

This first plaster is worn 2½ months and the second plaster the same length of time. Then the child is kept recumbent without plaster for two



FIG. 340.—Hoffa operation, stretching adductors; flexion, abduction and inward rotation. (*Young.*)

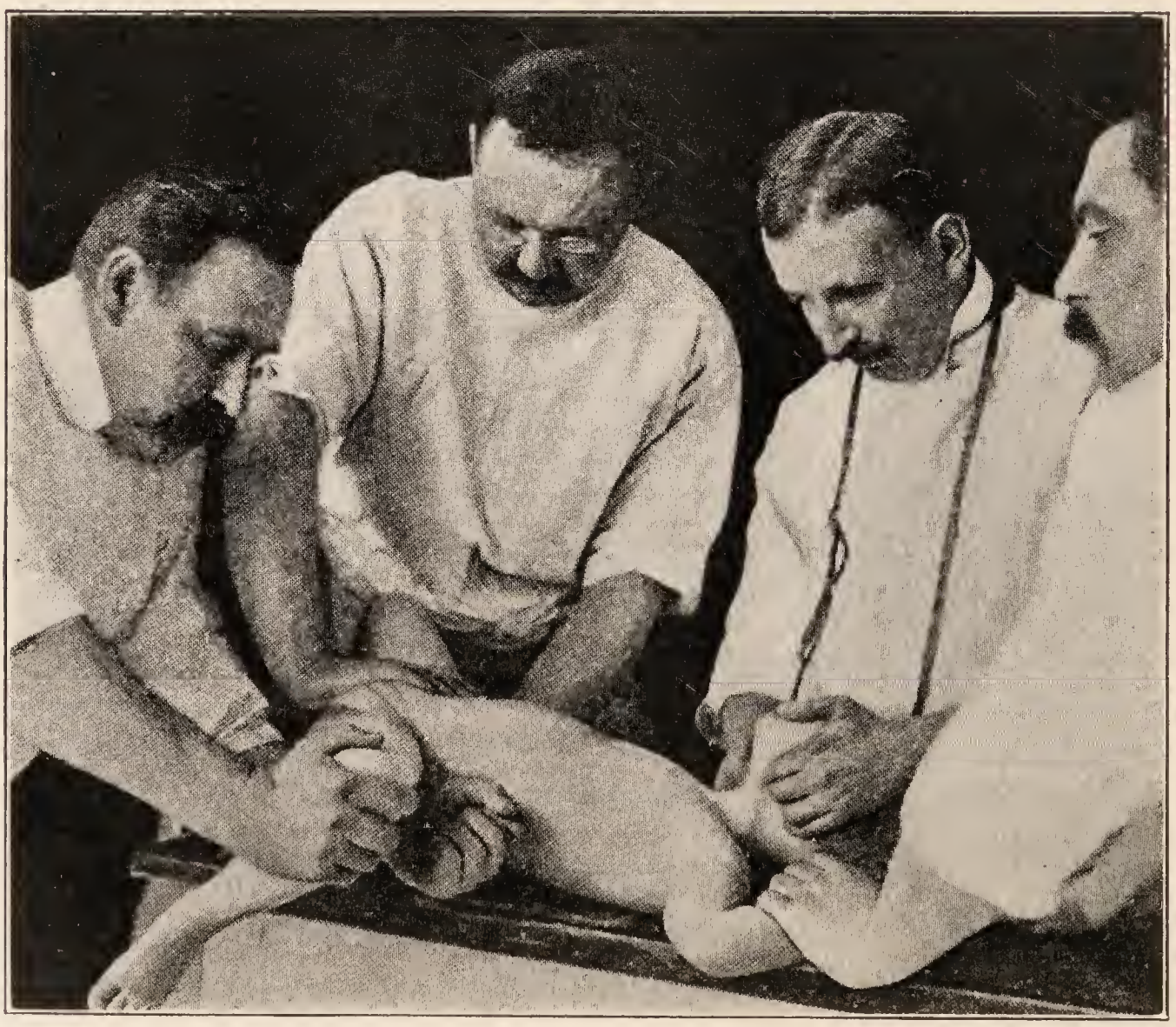


FIG. 341.—Hoffa operation. Stretching of capsule, flexion, abduction and outward rotation. "Reposition" using arm as fulcrum.

or three weeks, during which time the leg is massaged to overcome stiffness. During the following week the patient is allowed to stand with the hands supporting the weight on some piece of furniture. After that the patient is allowed to walk around her bed. After another week, she may be allowed to walk for five minutes at a time every hour. This is later increased to ten minutes. After a month the patient is allowed to walk with two canes. Three months after removal of the cast the patient will be able to walk without support and a year after should walk without apparent limp if the operation has been completely successful."

Hoffa uses his arm as a fulcrum for "Reposition." His fixation is in abduction and inward rotation (Figs. 340 and 341).

Bradford and Bartlett's Steel Plate and Rod Apparatus.

Doctor E. H. Bradford of Boston in conjunction with Mr. Ralph W. Bartlett devised a steel plate perforated for the admission of steel pins and perineal

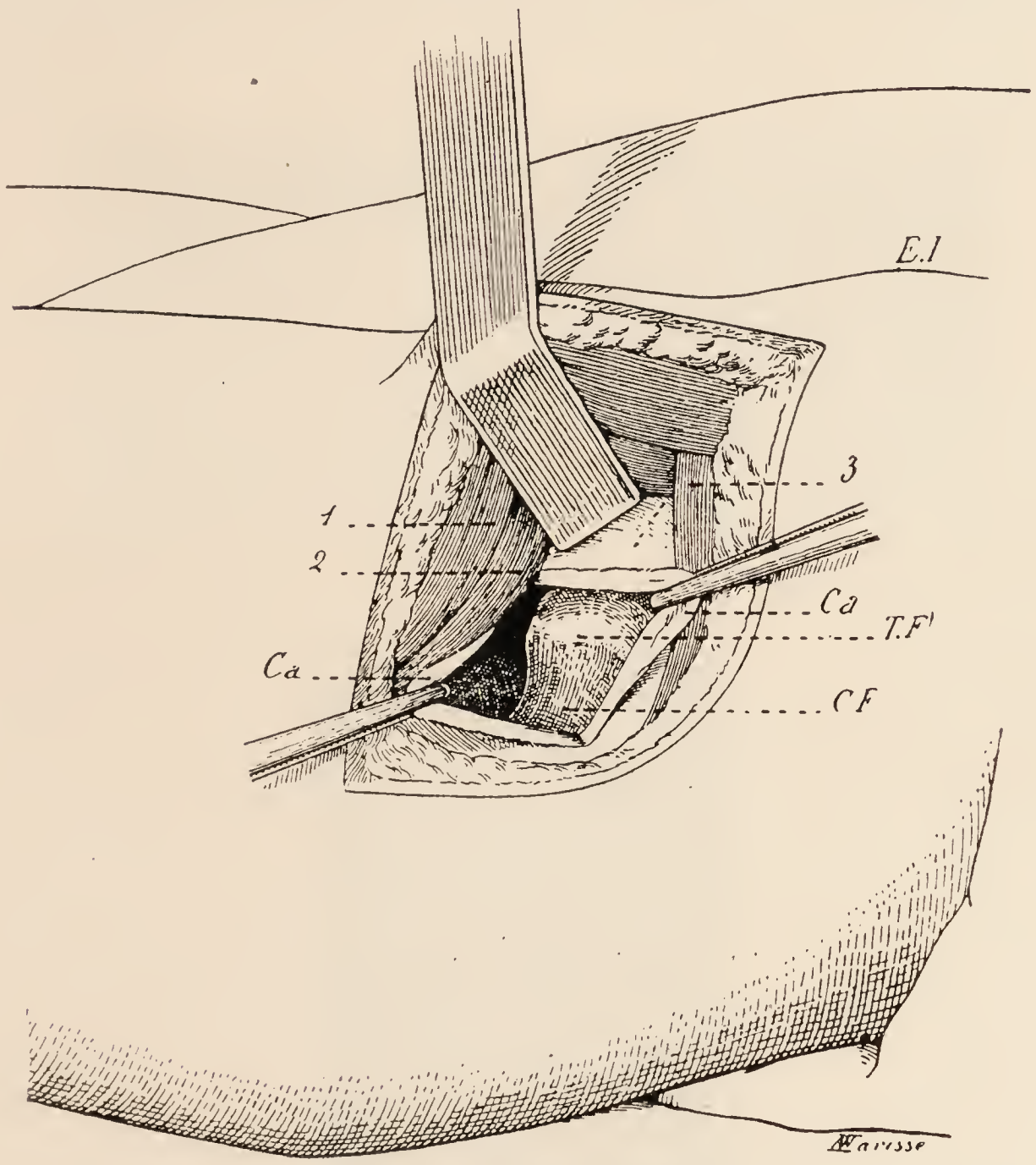


FIG. 342.—Hoffa's open operation. Incision of capsule. (*Berger and Banzet.*)

E.l., Poupart's ligament; 1, sartorius; 2, long head of biceps; 3, tensor vaginae femoris; *Ca*, capsule; *C.F.*, neck of femur; *T.F.*, head of femur.

posts for fixation of the pelvis and leverage traction rods and trochanteric levers for use in the mechanical reduction of Congenital Hip Dislocation in older cases and in those whose muscles were extremely rigid and would not yield to ordinary manipulative procedures.

Schede also devised an extension and abduction apparatus (Fig. 343).

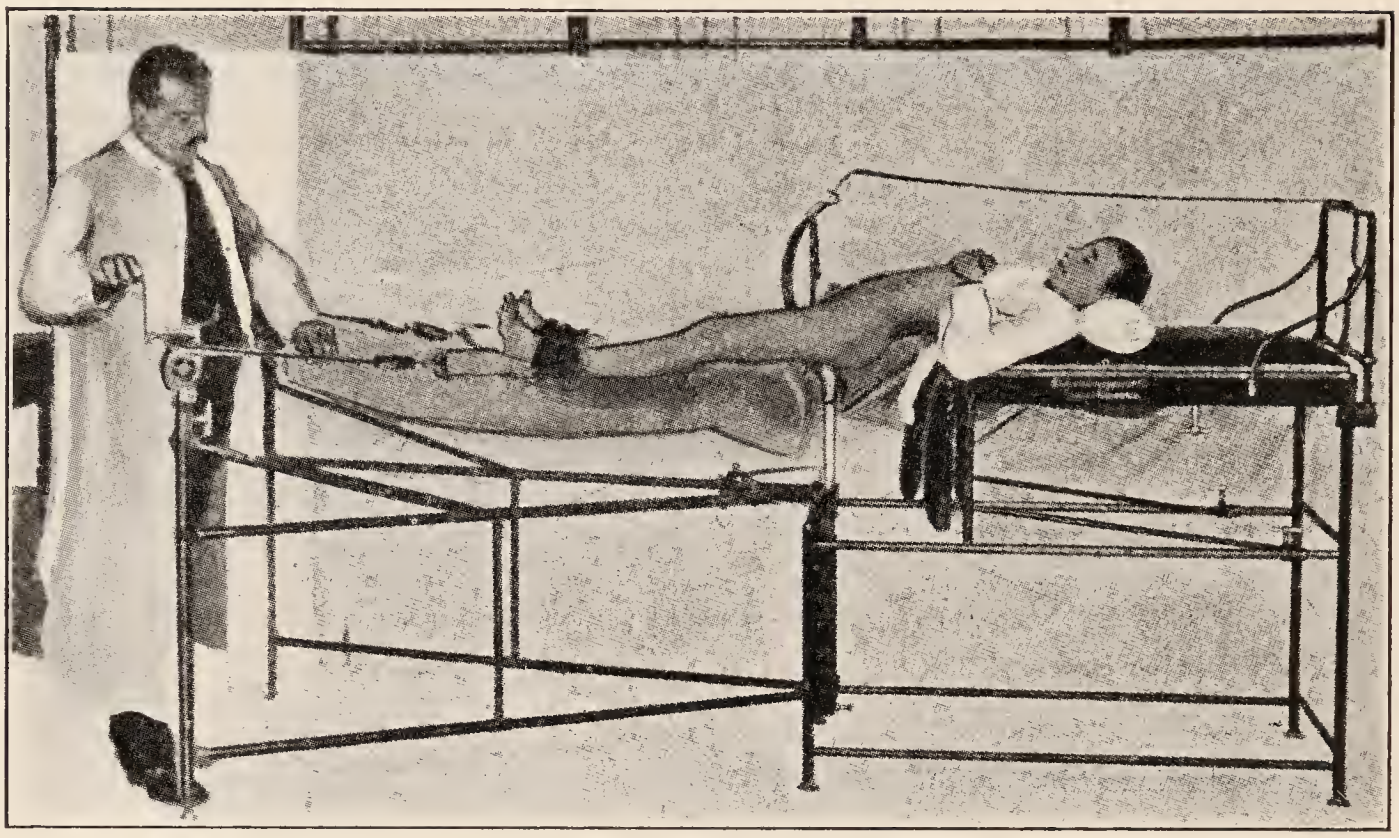


FIG. 343.—Schede's extension apparatus for dislocation of hip.



FIG. 344.—Sprengel-Smith-Peterson incision and spica.



FIG. 345.—Charcot hip associated with tabes dorsalis. (*Young.*)

Open Operative Treatment.

Hoffa recommends in cases where the acetabulum is extremely shallow open operation, after stretching the resistant muscles. His approach to the joint is through an incision extending from the anterior-superior spine to the trochanter, then by retraction of the muscles in the intermuscular spaces, incising the capsule and the head is then dislocated outward. The ligamentum teres is cut and removed, if found present. Contraction in the capsule is divided and through the wide space thus obtained a steel burr-like instrument about the size of the head of the femur is introduced and the acetabulum is bored deeper. The head of the femur is then replaced, the wound sutured and the leg put in abduction. Sprengle and Smith-Peterson extend the anterior incision along the iliac crest through the glutei which are deflected down to the acetabulum (Figs. 342 and 344).

Albee recommends where the posterior upper margin of the acetabulum is not adequate to hold the head in place, that a cuneiform wedge of bone be introduced into a split and elevated portion of the ileum at this point.

Charcot Hip.—The appearance of a luetic hip is shown in Fig. 345.

CHAPTER XIX

TUBERCULAR AND NON-TUBERCULAR AFFECTIONS OF THE KNEE AND OTHER JOINTS

Tubercular Knee Joint Disease.

Definition.—Tubercular Knee Joint Disease is a chronic lesion of the knee joint beginning usually in the epiphysis of the femur, tibia or patella or as a synovitis, resulting in partial ankylosis, recovery or complete destruction of the joint with ankylosis, in the order named.

Synonyms.—White Swelling, Tumor Albus, Tubercular Osteitis of the Knee, Chronic Tubercular Arthritis or Caries of the Knee. White Swelling is the commonest term applied.

Frequency.—Statistics would lead one to believe that the disease begins as frequently in the synovial membrane as in the bone, but Nichols[1] after examination of over 100 pathological specimens, concludes that it is primarily invariably osteal. About 45 per cent. are found in the tibia, 35 per cent. in the femur, 10 per cent. in the patella and 15 per cent. primarily in more than one bone.

Tubercular Disease of the Knee is seen next in frequency to the hip, which is less frequent than the spine in children. In adults we see this condition more often as a chronic synovitis probably secondary to some bone focus, whereas in children it is much more common as a bone disease. Although this disease occurs third in frequency of tubercular affections in childhood, it is more common in adults than the other two. There does not seem to be any marked difference in the frequency in males or females.

Localization.—Neither the right nor the left leg seems to be more frequently infected than the other. In the literature, one finds that the internal and external tuberosity of the tibia and the internal and external condyles of the femur are infected primarily with equal frequency. In the writer's experience, however, the inner side of the joint is more frequently first involved. Perhaps it is subjected to greater stress in weight-bearing, which may be a factor.

Pathology.—Associated with the primary bone focus, a general hyperaemia occurs in all of the peri-articular structures and with this we have a very marked thickening of the capsule and synovial membrane, which becomes involved. A fibrinous exudate occurs in the joint with the synovitis, which may assume the character of a villus arthritis, lead to adhesions, decreased joint capacity and diminished motion. The thickened hyperaemic tissues and granulations, after erosion of the bone surface, which may be present from extension of the disease, fill in the joint cavity, so that the tibia cannot be fully extended on the femur. Thus we find flexion a common symptom. With the extension of the disease, fibrilization of the cartilage and erosion of the opposing bone surfaces

[1] Trans. of the Amer. Ortho. Assoc., vol. xi.

readily lead later to bony ankylosis. Although the swelling and thickening of the peri-articular structures is a common symptom, palpation, as a rule, does not give definite fluctuation, but the joint has an elastic doughy feel and in only rare instances do we get the definite fluctuations of tubercular pus. The depressions usually noted on either side of the patella are filled in by this pathological thickening, so that instead of a protrusion, the patella may be noted as a depression. The whole joint has a fusiform shape with atrophy above and below the joint. In the synovial thickening or the variety in which excessive synovial fluid with fluctuation predominates, we may find hundreds of "joint



FIG. 346.—Early tubercular osteitis of the knee, showing general clouding of the joint, epiphyseal thickening, loss of tibial epiphyseal line and swelling of capsule.

mice" made up of pinched off pieces of villi from the synovial membrane. As its name indicates, the joint has a white pallid appearance and occasionally we note tortuous blue veins in the skin (Figs. 346, 347 and 348).

Etiology.—The etiology is similar to that found in tubercular disease in the spine and hip.

Symptoms. (1) *Onset.*—Like all tubercular joint and bone affections, the onset of this disease is slow, following some slight trauma, associated with arthritis or synovitis, but late the progress may be rapid and the symptoms so acute, that one is almost tempted to consider the condition an Acute Epiphysitis.

2. **Local Tenderness and Swelling.**—Unlike tubercular disease of the spine and of the hip, where the affected region is so deeply situated, in the knee, the trouble lying immediately under the skin, enables the clinician to detect the *swelling* incident to the disease and also make out extreme *tenderness* in the

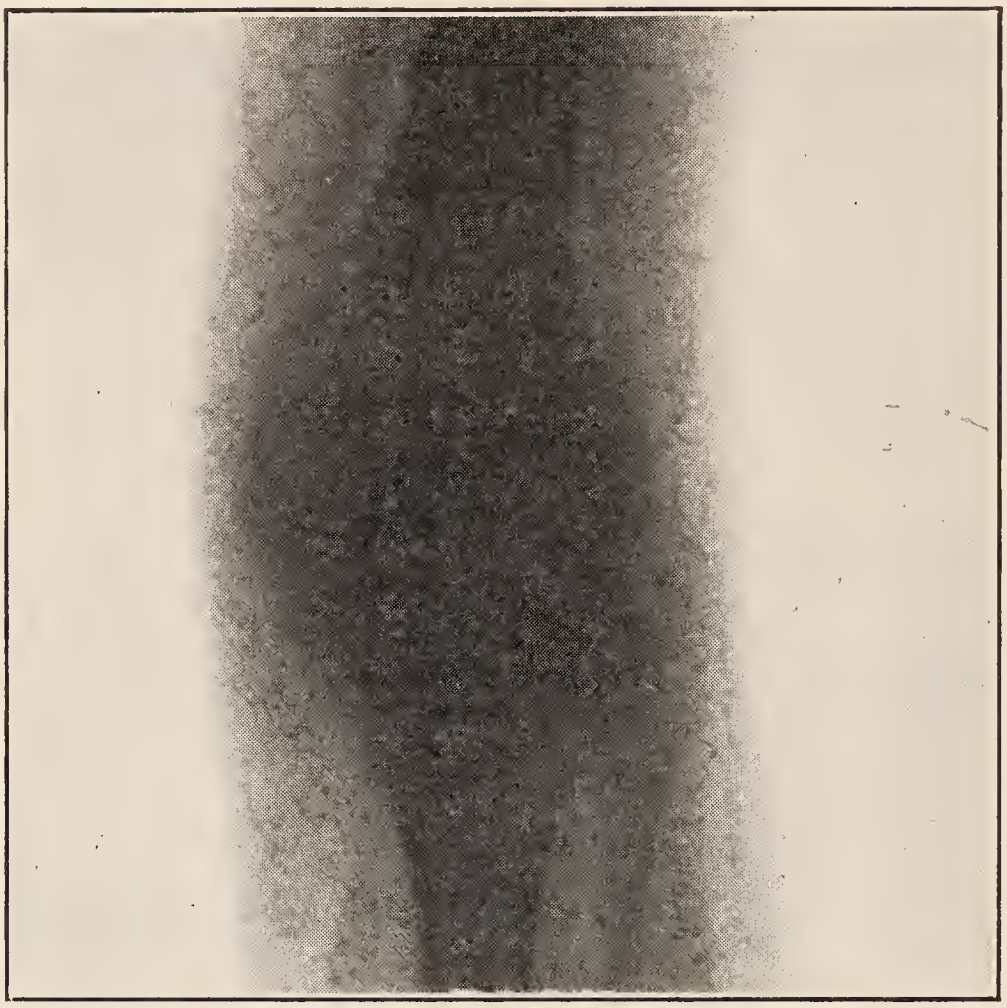


FIG. 347.—More advanced white swelling, greater clouding of joint outline, hypertrophy of epiphyses, narrowing of joint-cavity, partial ankylosis and foci of disease shown in femoral and tibial epiphyses.



FIG. 348.—Antero-posterior and lateral views showing complete ankylosis in tuberculosis of the knee, involving the tibia and femur as well as femur and patella. Epiphyseal atrophy.

region where the softened bone is. As a rule, the surface temperature is not raised, but local heat may be detected in a very acute joint. The swelling incident to the synovial type is associated with a chronic hydrops or " water on the knee" and this water cushion prevents contact between the opposing bones and hence the symptoms are less marked, but of a long chronic duration.

3. **Muscle Spasm.**—Like all tubercular joints, in the knee, we find marked muscle spasm, which manifests itself more in the hamstrings than in the extensors, owing to the joint structures being hyperaemic and thickened, so that early flexion is often found.

4. **Deformity.**—The deformity most frequently encountered is flexion, but in addition, we sometimes find overaction of the biceps, which pulls the tibia into an outward rotation and not infrequently produces a knock-knee. The continued spasm of the hamstrings also produces a subluxation of the tibia backward, which is one of the more difficult symptoms to overcome, owing not only to the spasm of the hamstrings, but to the intra-articular thickening.

5. **Limp.**—Lameness is early noted from the flexed position of the limb and pain incident to use.

6. **Pain.**—Pain comes from any sudden movement, especially when the opposing surfaces are eroded and may be so acute that the patient is forced to be bed-ridden and cannot bear the slightest jarring or change of position of the leg without serious discomfort. Night-cries are present in the acute stages.



FIG. 349.—Ankylosis at 110 degrees from white swelling showing scars of old sinuses.

7. **Shortening or Lengthening.**—During the early stages, there is a distinct swelling of the epiphyses and if measurements are made from the anterior-superior spine to the internal malleolus, the affected leg will be found to be the longer. In the later healing stages, even if the flexion and subluxation are overcome, which, of course, produce shortening, the leg will be found shorter than its mate, owing to the fibrosis, which takes place in the healing process, together with bone destruction and the inhibiting action on the growth of the epiphyses from the toxins of tuberculosis (Fig. 349).

8. **Atrophy.**—The circumferences of the thigh and calf above and below the joint, when compared with similar measurements made of the sound side, will demonstrate even at an early date the shrinkage incident to non-use and the disease. It is quite characteristic.

Diagnosis.

In making a diagnosis of this condition, one is entirely influenced by the insidious onset, chronic course, family history of tuberculosis, fusiform shape of the joint with atrophy above and below, pain, night cries, tenderness and

flexion or flexion and subluxation deformity. In other infectious conditions of the knee, more than one joint is involved as a rule, except in penetrating wounds with sepsis. Of course, the X-ray is the most valuable means of diagnosis of all, as tuberculin tests will not point necessarily to the part of the anatomy involved.

Differential Diagnosis.

1. **Trauma.**—After a minor contusion or sprain of the knee, where one sees simple Acute Synovitis, usually with effusion into the joint, and in children

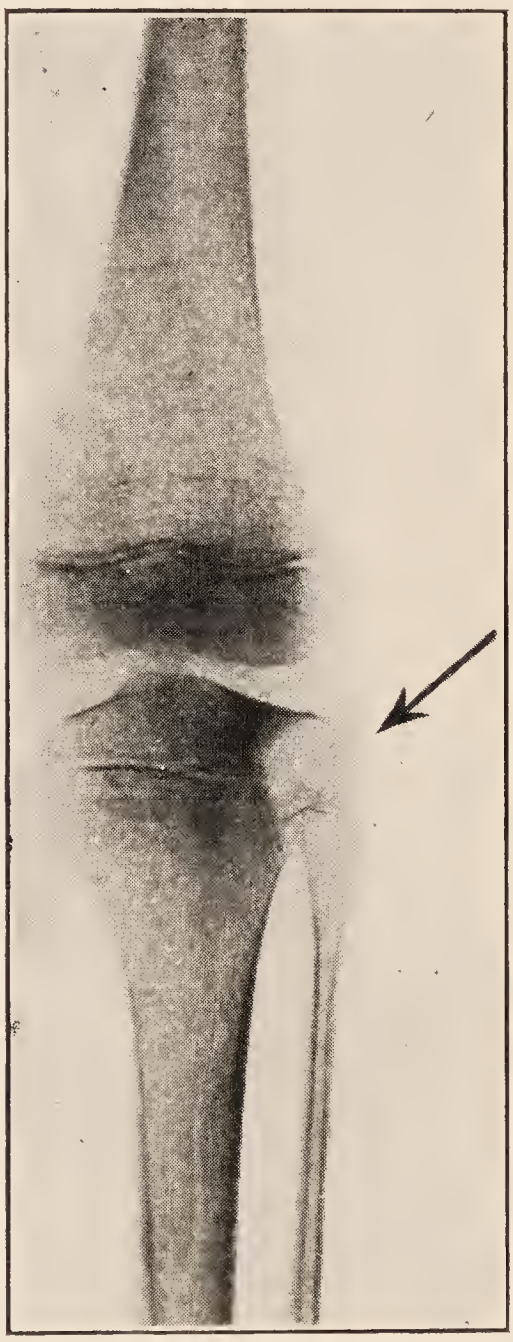


FIG. 350.—Haematogenous infectious Epiphysitis of tibia secondary to acute osteomyelitis in opposite femur.



FIG. 351.—Acute osteomyelitis of tibial diaphysis.

especially, we should bear in mind that this may be a predisposing cause of tuberculosis and the condition should not be treated too lightly. In adults, simple synovitis of the knee usually clears up rapidly and completely unless the injury has been more severe and the condition becomes chronic. Chronic Synovitis may be a manifestation of Haemophilia. In Villous Arthritis and Lipomata of the knee joint we may have a "pinching" of the fringes between the bones and a resultant Chronic Synovitis. Housemaid's Knee shows itself as a swelling confined more to the region of the prepatella bursa, often due to a blow or injury to the patella only.

2. **Suppurative Arthritis.**—This is usually associated with a punctured wound of the knee joint, accompanied by fever, symptoms of acute infection and rapid course. In rare instances, Acute Epiphysitis is an evidence of Haematogenous Infection without a penetrating wound into the articulation (Figs. 350 and 351).

3. **Infectious Arthritis.**—This is usually poly-articular, so that we may find that in addition to the knees, the hands are involved at the inter-phalangeal joints or the metacarpo-phalangeal joints, the cervical spine, the hips, the tempero-maxillary and other joints and are all traceable to a bad tooth or infected tonsils or antra or frontal sinus. Some of these cases are attributable to the gastro-enteric tract, a chronic appendicitis, or the genito-urinary tract.



FIG. 352.—Neisserian ankylosis.

The latter is more often due to a Neisserian Infection. Once established, an infectious joint may act as a focus for involving other joints (Figs. 352 and 362).

4. **Rheumatism.**—Rheumatic Arthritis or Rheumatic Fever is more frequently a poly-articular disease characterized by sudden onset, high fever, prostration, sweating and immobilization of the joints from acute pain. It is often a family diathesis and is probably of infectious origin.

5. **Rheumtoid Arthritis, Osteo-arthritis and Still's Disease.**—These may be of the hypertrophic or atrophic variety depending upon whether the bony epiphyseal and peri-articular constituents are overstimulated in lime salt deposition and hypertrophied by new bone formation or inhibited and atrophied. Still's Disease is an atrophic variety seen in children. All are probably traceable to a focal infection and variations of Infectious Arthritis (Figs. 384 and 385).

6. **Syphilis of the Knee.**—This is more often seen as a late manifestation of lues elsewhere, more often following a spinal lesion of Tabes Dorsalis and characterized by sudden onset and rapid bone destruction. These are known as Charcot's Joints (Fig. 363).

7. **Sarcoma of the Knee.**—This is more often a diaphyseal rather than an articular affection and leads to rupture through the periosteum in all directions. Its origin is in the medullary canal, being metaphyseal and not epiphyseal. The pain and disability are most marked. The growth and the course of the



FIG. 353.—Osteo-sarcoma of femur with pathological fracture.

disease is very rapid and they are not affected by treatment. Amputation often results in metastasis or recurrence in the stump. Radium and X-ray avail little in permanent arrest of the growth (Fig. 353).

8. **Ossified Haematoma.**—Extensive Ecchymosis near a joint, if not absorbed nor infected through the blood stream, may undergo calcaneous changes and be ossified.

9. **Neuromimesis.**—Hysterical and Neurotic children may feign and imitate the limp and flexion seen in some neighboring child, who has true White Swelling of the Knee. A diagnosis is readily made by the absence of atrophy

and the fusiform swelling and the muscle spasm present will often disappear when the child's attention is attracted in other directions.

10. **"Internal Derangement of the Knee," Loose Bodies in the Knee, Osteochondritis Dissecans, Osteomata and Osteochondromatosis.**—All of these are differentiated by the X-ray except in the case of torn or loose semi-lunar cartilages, which as a rule show nothing in the radiogram.

Treatment.

Immunization.—Aside from the constitutional and immunizing treatments already described in tubercular spinal and hip affections, including tonics and tuberculin, the aids of fresh air, sunlight, "hi-lite," "violet-ray" and "Alpine" Quartz lamps, the knee lends itself readily to the employment of Bier's passive Hyperaemia, which is obtained by means of an Exmarch rubber bandage applied for prolonged periods above the knee to partially restrict the return flow of venous blood. Under the theory that the retardation of the blood stream with the phagocytes and opsonins present, may more rapidly combat the Tubercle Bacilli, this treatment is employed by few surgeons now, as the results were not commensurate with the claims made for it.

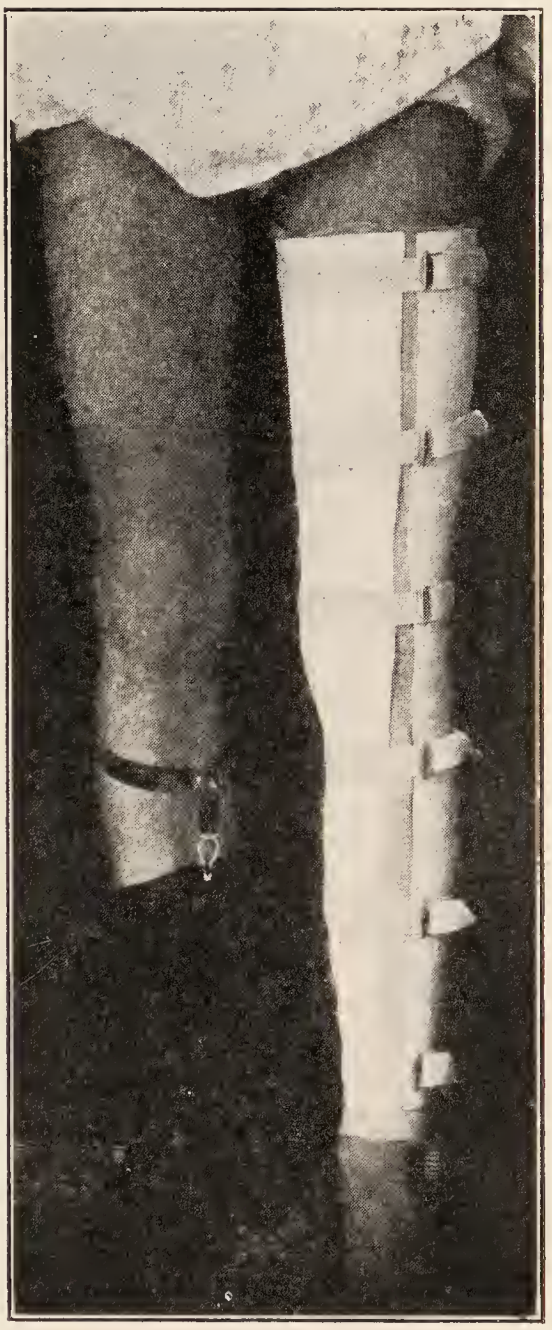


FIG. 354.—Split plaster or celluloid splint for knee-joint disease. (*Young.*)

Mechanical Treatment.—The knee, being situated in the centre of two long levers, lends itself readily to mechanical treatment both in fixation and traction.

Fixation.—Fixation is accomplished best by the plaster of paris cast, which may be applied from the toes to the groin or just above the ankle to the groin, depending upon the acuteness of the symptoms. If the knee is flexed, a series of casts may be employed, the knee being straightened a little at each successive application, as the muscle spasm subsides with rest, or an elipse may be cut out of the cast over the knee with its ends joined by a straight incision under the popliteal space into which progressively thickened wedges of wood may be forced in the progressive straightening (Fig. 354).

Traction.—As a rule, during the early and acute stages, however, Buck's extension with adhesives to the knee *must be employed* to effect traction for weeks or months until the muscle spasm subsides and healing begins. With flexion, this may be accomplished by having the patient lie on the affected side habitually or by use of a Double Inclined Plane if the patient is on the back. If the knee is flexed and also subluxated, traction must be effected at the foot of the bed as well as under *the head of the tibia* to a pulley in the top of a Balkan

frame or similar device, otherwise the traction in the plane of the bed would not only intensify the pain, but lead to a knee that when straightened was badly subluxated. This method is thoroughly scientific and far preferable to forcible straightening under an anaesthetic, except in cases of mild muscle spasm or where the traction had been thoroughly and unsuccessfully tried in cases of long standing and the hamstrings showed evident adaptive shortening and myotomies were indicated (Figs. 355 and 356).

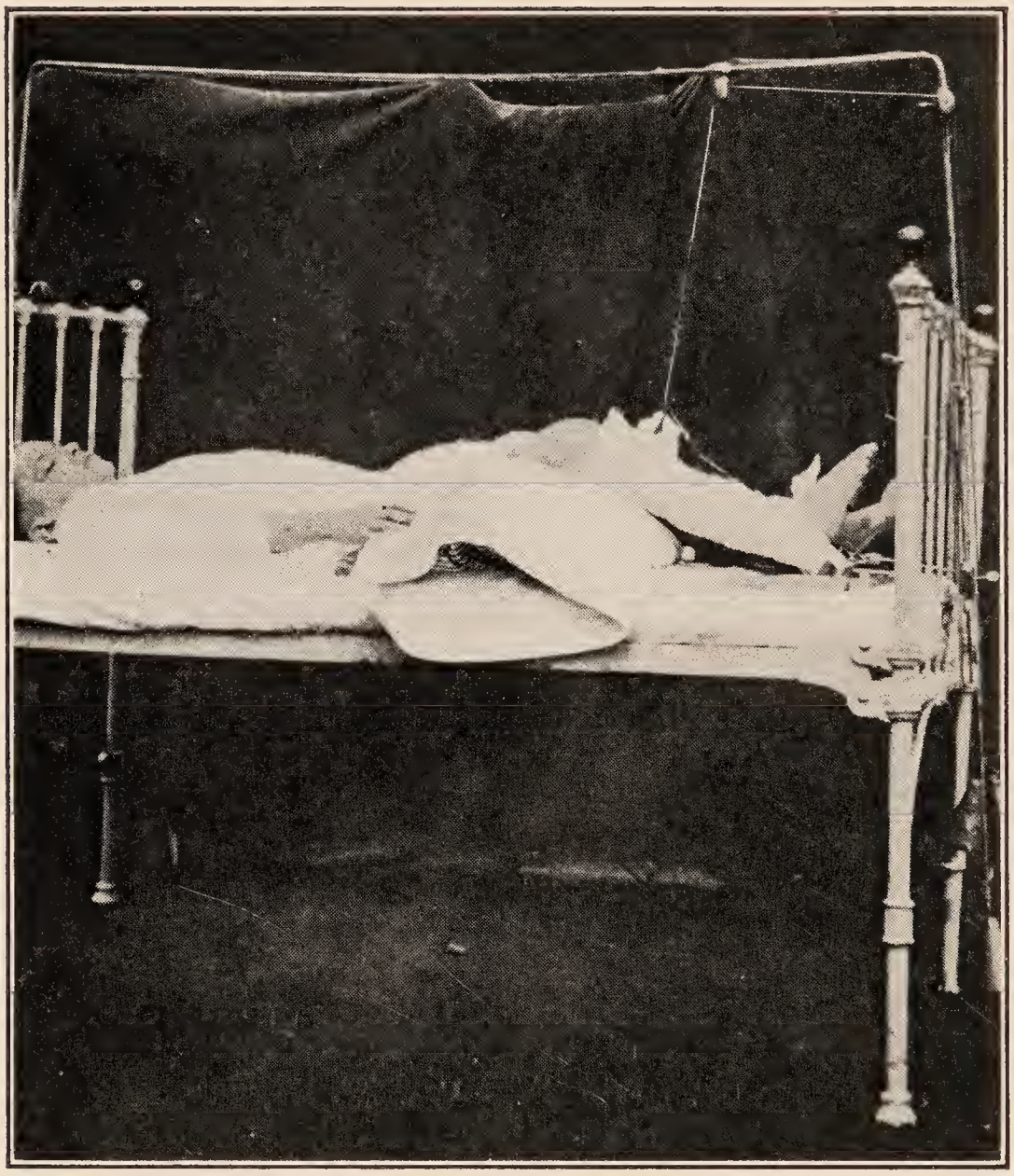


FIG. 355.—Horizontal and vertical traction to overcome flexion and subluxation in tuberculosis of the knee. Author's technique.

Forcible Straightening.—Whitman suggests anaesthetizing certain flexed and subluxated cases, where rapidity of correction is necessary. He turns the patient face downward, with the thigh against the operating table and by firm pressure against the posterior aspect of the head of the tibia overcomes the subluxation and then extends the leg, corrects the flexion and applies a cast. This he calls "Reverse Leverage."

Bradford and Goldthwait devised a "Genuclast," which was a large two pronged fork, on the ends of which was a strap attached to rest against the front of the lower extremity of the femur and a screw traction belt to go behind the head of the tibia effective from the two prongs to pull it forward and correct subluxation before the handle of the fork was raised to effect extension (Fig. 357).

Thomas Knee Splint.—After muscle spasm had largely subsided, to continue traction and prevent relapse, Thomas of Liverpool devised the well-known Thomas Knee Splint, which had such extensive application for leg and thigh wounds in the World War. For application in Tuberculosis of the knee, as modified by American surgeons, it consists of a padded leather covered steel ring, rather more rounded on its posterior than anterior half to fit snugly against the tuberosity of the ischium and surround the upper thigh at the groin and under the buttock. This ring is set at an angle of about 30° downward

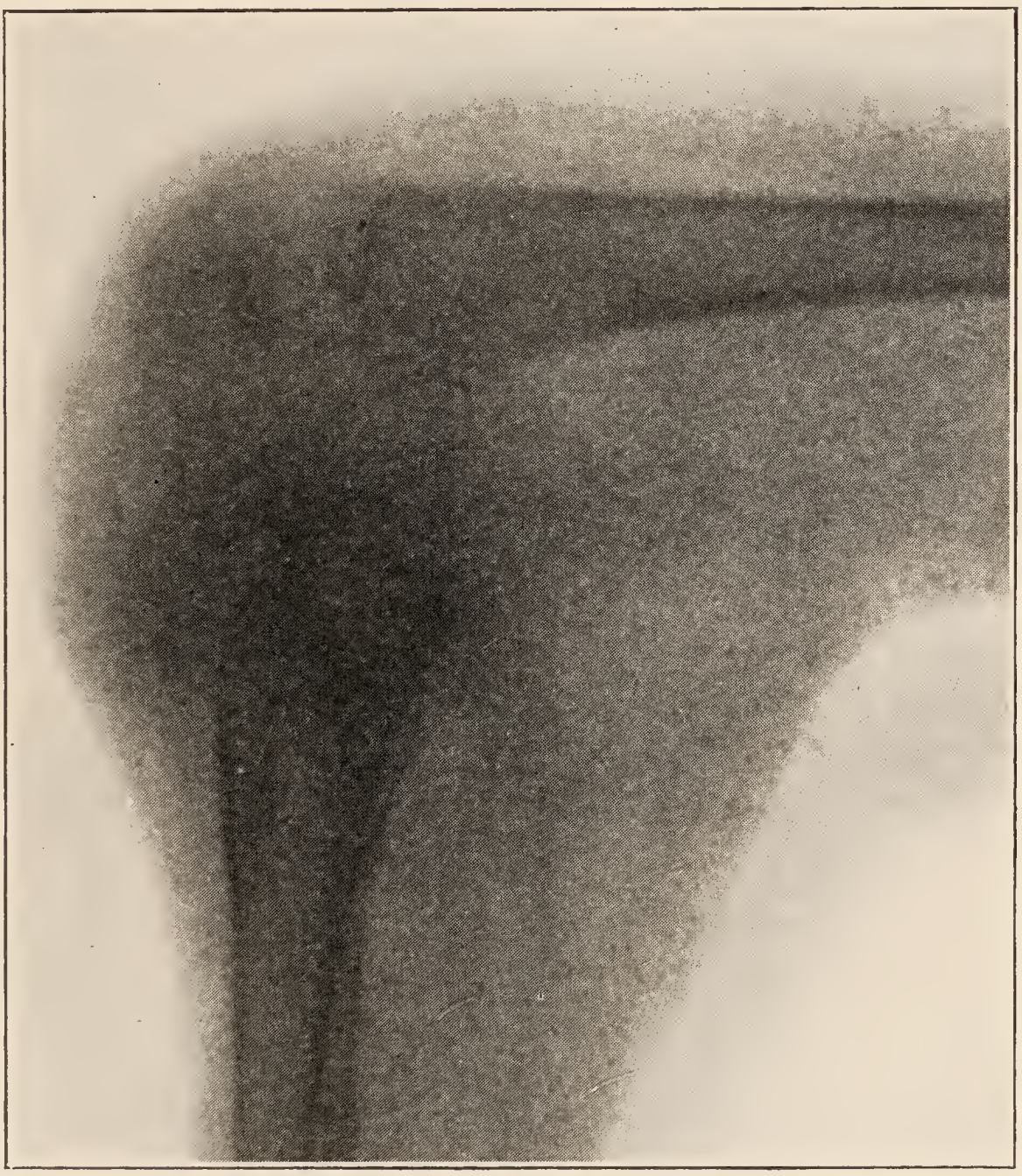


FIG. 356.—Rectangular ankylosis and subluxation in old tubercular knee.

and inward and 45° from before downward and backward with the external and internal uprights to which it is attached. These uprights converge, so that two or three inches below the foot, they are three or four inches apart and joined together by a transverse piece. About an inch above this transverse piece is an axle holding tape slots for traction webbing and this axle is controlled by a ratchet, catch and spring, which can be turned and wound up by an ordinary clock key, so that when the pull is thus effected on the webbing, traction is made as by weight-traction, the perineal ring offering resistance. This brace is used in *acute* cases with the addition of a short plaster knee cast and is very serviceable. A two or three inch cork-soled shoe is put on the foot of the well leg and the patient equipped with crutches, if the surgeon deems it expedient

not to allow the patient to walk on the end of the brace. Occasionally if a patient has progressed to satisfactory convalescence, the foot piece is cut in the centre and entered in slots in the shoe heel, the uprights being of such length as *not* to permit the heel of the foot to reach the sole of the shoe and thus afford an air cushion under the heel, the patient walking in slight equinus. This is known as a "Caliper Brace" and the uprights are held in place by a strap around the ankle (Fig. 20).

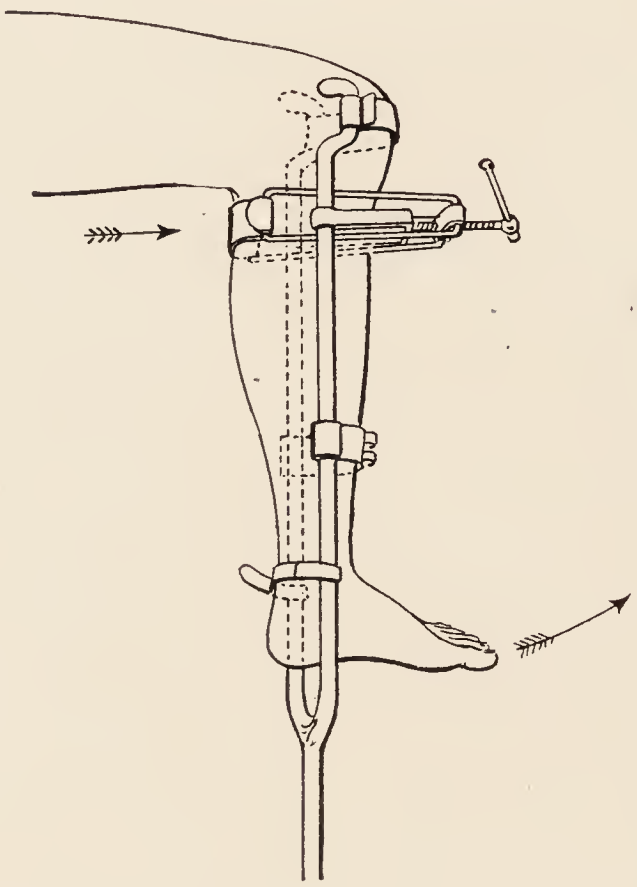


FIG. 357.—Author's modification of Bradford-Goldthwait genuclast with forward traction.

Operative Treatment.

Owing to a large part of the components of the knee joint being subcutaneous, it is possible in many instances of early bone disease to remove the offending focus without invasion of the joint proper. This, however, is more often required and done in adolescence and adult life, as one hesitates to disturb the epiphyses in early childhood for fear of stopping growth.

Erasion.—However, with the aid of radiographs one can locate an early superficial epiphyseal focus in which the disease has not extended to the joint and is strictly a primary abscess and has not become a secondary abscess into the surrounding soft parts. By incision and curettement much, if not all, of the softened bone may be removed, the cavity well irrigated with normal or hypertonic salt solution and the incision tightly closed with primary healing. The joint is saved thereby, the duration of the disability is greatly shortened and is an operation of choice in selected cases. This must be done in a bloodless field to lessen the danger of tubercle dissemination (Fig. 358).

Excision.—In adults with *extensive involvement* of both bones, destruction of cartilage and synovial membrane, excision beyond the focus in healthy tissue will save months of suffering and invalidism and as both result in ankylosis, the more speedily this is obtained, the better it is for the health and strength of the patient. This should aim to produce close approximation of the femur

and tibia and be done in a bloodless field, with a Gigli- or Fret-saw from behind forward.

Amputation.—This extreme measure is rarely required, except in extensive secondary infection with multiple sinuses, a septic chart, failing heart and as a life saving measure.

Injections.—Intra-articular medication by means of iodoform and glycerin, iodoform and oil and the like have fallen into disfavor and are rarely employed by the best authorities.



FIG. 358.—Tubercular knee after erasion. Useful degree of motion up to 30 degrees or more of flexion exists.

Treatment of Sinuses.—The tidal irrigation of hypertonic (5 per cent.) salt solution will be found to be most effective as fully described under Tubercular Disease of the Spine and Hip. Dakin's solution is valueless in such cases.

Non-tubercular Affections of the Knee.

Acute Synovitis.—Acute synovitis is seen after some injury and is characterized by diminished function, swelling, pain and often fluctuation from excess of synovial fluid in the joint. On tapping the patella with the finger, it can be

driven down, felt to strike the femur and will then "float" up again. Immediately after injury, such a patient should be put to bed, to take the weight off the injured part. Moist compresses of witch hazel, very weak alcoholic solution or even plain water covered with oil-silk, oiled paper or glazed cotton, to keep in the moisture, should be bandaged on over night for a night or two. As the injury improves, adhesive strapping of one inch strips of Z-O surgeons' plaster, to extend 8 to 10 inches above and below the front of the joint, will immobilize it and allow rest and repair and even permit the patient to get about a bit. Transverse strapping to extend two-thirds around the front of the limb above and below the joint and a roller bandage will further help the fixation. Rarely is a plaster cast required. Later in convalescence and in weak knees or those prone to injury, a flannel bandage applied well below and above the joint will be found serviceable or an elastic knit stocking may be employed provided it extends well above and below the joint, say 8 or 10 inches in an adult. Contrast baths and massage should complete the cure in the severer cases.

Chronic Synovitis, Loose Cartilage and "Internal Derangement" of the Knee (Hey).

Chronic synovitis is usually attributable to one of the following conditions: A loose or torn semilunar cartilage, which is recognized by recurrent attacks of hydrops articuli or so-called "water on the knee" and frequently the patient will describe a "locking of the knee," when it is flexed, so that it cannot be extended. This locking may require the assistance of a surgeon to reduce, which may be accomplished by flexion and outward or inward rotation of the tibia on the femur if the relaxation of the joint is sufficient to permit it. Tenderness over the loose cartilage, or the tear in it, is frequently present and one can even palpate the movable cartilage at the inner or outer side, as the case may be. The inner cartilage more often suffers and this is sometimes attributable to a twist of the femur on the tibia, as one turns to look behind, with the foot firmly planted on the ground, or it may be caused by jumping and landing on the heel instead of on the ball of the foot or a fall and twist of the leg on the thigh. Nothing short of a radical arthrotomy with the removal of the loose or torn cartilage will cure these chronic recurring cases.

This operation, of course, should be done under the strictest asepsis preferably with an Esmarch and a bloodless field with the knee slightly flexed by a sand bag. A vertical incision is made one half an inch beyond the patella margin about three inches long, the centre of this incision being near the lower margin of the patella. The skin is then retracted away from the patella and with a second knife, the capsule is vertically incised over the cartilage, which is detached at its anterior and posterior ends keeping as close as possible to the bone, so as to cut the synovial membrane as little as possible. If any loose fringes of synovial membrane or fatty masses are present and seem likely to be pinched between the bones, these also should be removed. For the comfort of the patient, it *should be an invariable rule* before suturing the capsule to *flood the joint with ether*. The capsule should be sutured with interrupted #2 plain catgut and it should be tied instrumentally and not with the hands. The skin is sutured with #2 chromic catgut subcutaneously. No fixation is required. Baking, massage

and contrast baths will often complete the cure and rapidly restore function, if given two weeks after the operation. It is to be noted the capsular incision is an inch lateral and not under the skin incision. If the ether is omitted in the joint before suturing the patient during convalescence will suffer much more.

Henderson states[1] "The semilunar cartilages rank first as a cause of mechanical derangements of the knee. The English literature contains many reports, notably by Rutherford Morison and Sir Robert Jones, of large series of patients operated on, but the American literature is scanty. This can be ex-



FIG. 359.—Osteoma of knee in intercondylar notch preventing extension. Four years duration. Developed in anterior crucial ligament after traumatic tearing from tibia. Complete cure on removal.

plained, partly at least, by the fact that games such as rugby and soccer are participated in by a much larger number of persons than in America, and also by the fact that in the mines in the region of Newcastle, where the condition is very common among the miners, the workers labor in low seams, which makes it necessary for them to squat on their heels with knees flexed and feet everted, a most favorable position for damage to the menisci. The fact that the internal

[1] Surg., Gynec. and Obstet., May, 1922, vol. xxxiv, No. 5, pages 682–683.

cartilage is more often damaged than the external can be explained by anatomic facts. The internal cartilage is so firmly attached to the internal capsule that when caught between the bones, if the force continues, the cartilage will tear or fracture before it is torn from its moorings.

"Rutherford Morison has described in detail many types of fractures but the so-called 'bucket-handle' is probably the most common. This specific tear is a longitudinal rip in the middle portion of the internal cartilage, leaving the torn area attached at the anterior and posterior ends, the loop thus formed slipping into the intercondylar notch. Full extension is thereby prevented and the joint locked in slight flexion. A definite pathological condition as evidenced by a tear or fracture is almost invariably present when the derangement is due to the internal cartilage.

"The external semilunar cartilage at its periphery is loosely attached to the capsule and this fact permits the meniscus a certain mobility and allows it to glide out of harm's way. If it is the cause of the derangement, it usually is found



FIG. 360.—Osteoma removed in case Fig. 359; actual size. Portion to left ligamentous, containing also sesamoid bone.

crumpled up rather than torn and is more apt to prevent flexion than to limit extension. The condition is usually a loose rather than a torn cartilage.

"The primary derangements should be treated conservatively but repeated lockings with periods of disability make it necessary to resort to surgery. The X-ray is of no value as these fibrocartilaginous menisci cast no shadows. The procedure of injecting the joint with oxygen, thus throwing the fibrocartilages in relief, is too dangerous a procedure to warrant its use (Figs. 359 and 360).

"Loose osteocartilaginous bodies are also a cause of mechanical derangement of the knee, but the symptoms are more transient and the disability less than when the menisci are at fault. In numbers, they range from one or two up into the hundreds. Usually the patient has palpated them and often is able to force them out where the surgeon can also feel them. They are readily shown by the X-ray. Not infrequently, both joints are involved. They are of chief interest from the view-point of etiology. As a primary premise it may be accepted that trauma, direct or indirect, is a factor, but not the sole factor in their production. They may be grouped under three divisions. They may arise from the internal condyle just anterior to the insertion of the posterior ligament. A satisfactory explanation of this peculiar condition, seen only in the knee joint, has not been advanced, but Koenig, in 1887, offered the theory that it was due to blockage of an end artery and called the condition "osteochondritis

dissecans." They may arise incidental to osteoarthritis. The marginal osteophytes or ecchondroses become chipped off and wander freely about the joint cavity and increase in size, obtaining their nourishment from the joint fluid. Occasionally the synovial membrane undergoes a peculiar change, becoming thick and pleated, forming bulbs which become osteocartilaginous on the tips, and, as they increase in size, drop off to migrate as free bodies. They take nourishment from the joint fluid, further increase in size, and may be so numerous that in palpating the knee, one is reminded of a sac of marbles. This condition is called "osteochondromatosis," and is found also in the elbow or shoulder joint. It suggests in some ways a benign neoplasm. Osteocartilaginous bodies rarely arise from the tibia or patella. Loose foreign bodies of extrinsic origin are of very rare occurrence in civil practice (Figs. 361 and 362).

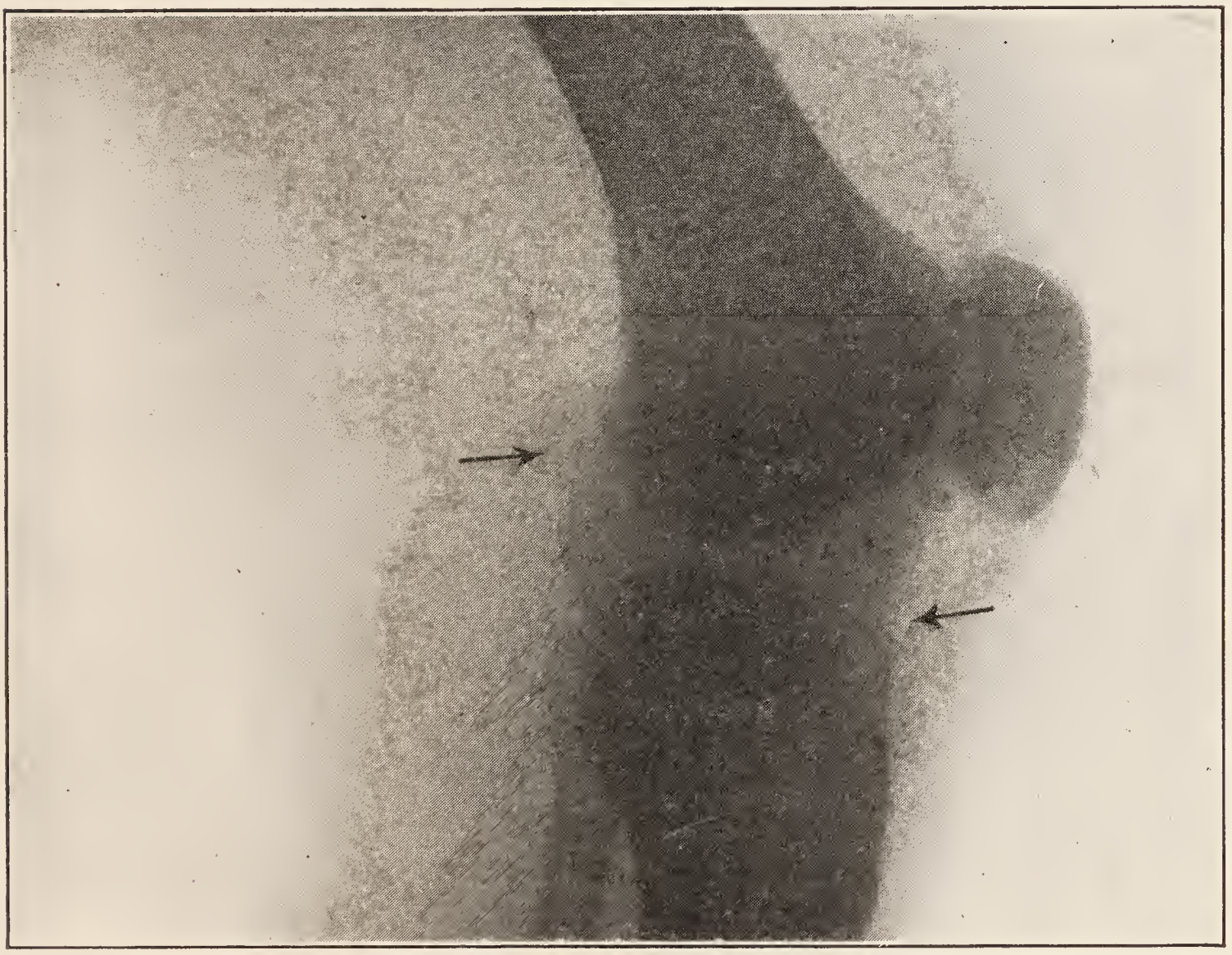


FIG. 361.—Osteochondritis dissecans.

"The incisions to be used in the removal of the causes of mechanical derangement are of importance because the joint cavity is not easily explored. When one of the semilunar cartilages is to be removed, either the internal-antero-lateral or the external-antero-lateral are to be preferred to any other. When a thorough search of the anterior compartment of the knee joint is to be made, the longitudinal split patella incision is the incision of choice. When the bodies to be removed are in the posterior compartment, the posterior, internal lateral or the posterior, external lateral incisions made with the knee flexed to a right angle afford ready access to a rather inaccessible region and even a fair degree of opportunity for visual inspection."

Following traumatization of the crucial ligament, some years previously, a patient under the writer's care developed an osteoma. A torn bit of the tibia acted as a nucleus with a synovial cartilaginous pedicle. This osteoma was in the intercondylar notch and was approximately one by two inches in size when removed,[1] having been developing several years after the original traumatism.

For overgrowth of one of the Tibial Spines, the author in two cases found intraligamentous removal easy through the vertically split patella incision.



FIG. 362.—Osteochondromatosis. (*Courtesy of Doctors Lutz and Bowers.*)

Charcot's Disease of the Knee.

Associated with Locomotor Ataxia (Tabes Dorsalis), as a late manifestation of syphilis, we may see sudden involvement of a joint, more frequently the knee. The other joints are much less frequently involved in the following order, the hip, the shoulder, the tarsus, the elbow, the ankle, the wrist, the jaw and the spine. When the leg is involved, we may have an extensive curvature of the leg, more often knock-knee with instability (Fig. 363).

Pathology.—Injury is usually an exciting cause and it may amount to a pathological fracture from weakened bone usually near the joint and the joint changes consist, as a rule, of rapid swelling, which may come on in a few hours, with degenerative changes in the synovial membrane and cartilage and with erosion of the joint surfaces, so that the normal appearance of the joint is soon entirely lost. There may be hypertrophic overgrowth changes above and below the joint surfaces and the capsule and peri-articular structures are much infiltrated, swollen and lengthened, so that the joint is so relaxed that some bracing may be required to afford adequate support.

Prognosis.—The prognosis for the restoration or recovery of a joint seriously involved with Charcot's Disease is remote.

[1] Annals of Surg., 1903, vol. xxxvii, pages 84–86.

Treatment.—Early recognition and immobilization will frequently save greatly impaired function. One should be on the qui vive in Locomotor Ataxia for such a complication. In addition to supporting braces or casts, which are sometimes required in affections of the extremities, one must also use spinal braces or jackets or bone graft from the Tibia for the prevention and support of the spine in this disease.

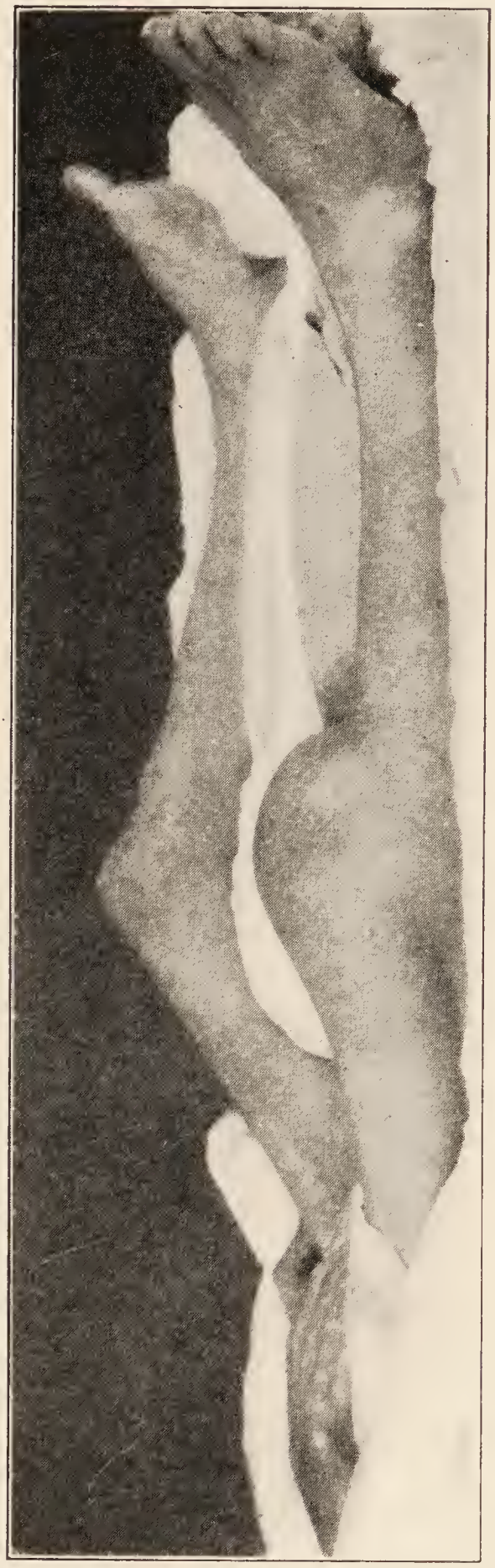


FIG. 363.—Charcot's disease of the knee. Somewhat similar at times in appearance to white swelling, but distinguishable by association with tabes dorsalis. (*Young.*)

Housemaid's Knee.

The pre-patella bursa may be enlarged from some blow or trauma and a congestion and an inflammation of the bursa may ensue. If this persists and does not yield to strapping with adhesive plaster and immobilization, or if it has been in existence for some time as a chronic affection leading to pain of moderate degree, it may be necessary to either draw off the contained excessive fluid with a trochar or aspirator or even it may require a radical curative operation of excision of the entire bursal sac.

Pre-tibial Bursitis.

Lying immediately behind the patella tendon and extending from the joint to the anterior tibial tubercle is a bursa about the width of the patella tendon, which may, as a result of injury, become inflamed. This also may be involved secondarily as a complication in the infectious diseases. As in all such conditions, the treatment consists of immobilization, counterirritants or the application of local heat by baking, the cautery or hot air blast. It is rarely necessary to aspirate or incise this bursa. This bursa is to be distinguished from the superficial bursa immediately over the tibial tubercle, which may also in certain instances be inflamed and require treatment.

Schlatter's Disease.

This condition consists of an enlargement of the anterior tibial tubercle and apparent separation of it along with the epiphysis from the diaphysis of the tibia. In a lateral X-ray view of this condition a tongue-like process projects

down from the lower portion of the epiphysis to the region of the anterior tubercle. It is more often seen in boys after puberty, who are engaged in athletic sports and is a result of some injury, as a rule. It is accompanied by an elevation of the surface temperature, pain and discomfort on all motions involving the extension of the leg on the thigh and is associated with the enlargement of the pre-tibial bursa. Occasionally this condition arises from delayed ossification and attachment of the anterior tibial tubercle to the shaft of the bone and in these cases, it is bi-lateral. There may be fusion of the upper epiphysis and anterior tubercle epiphyses. From injury, it is more often uni-lateral. It has been stated that it is sometimes associated with Rickets, Syphilis and Tuberculosis. If due to injury, immobilization usually results in repair. If, however

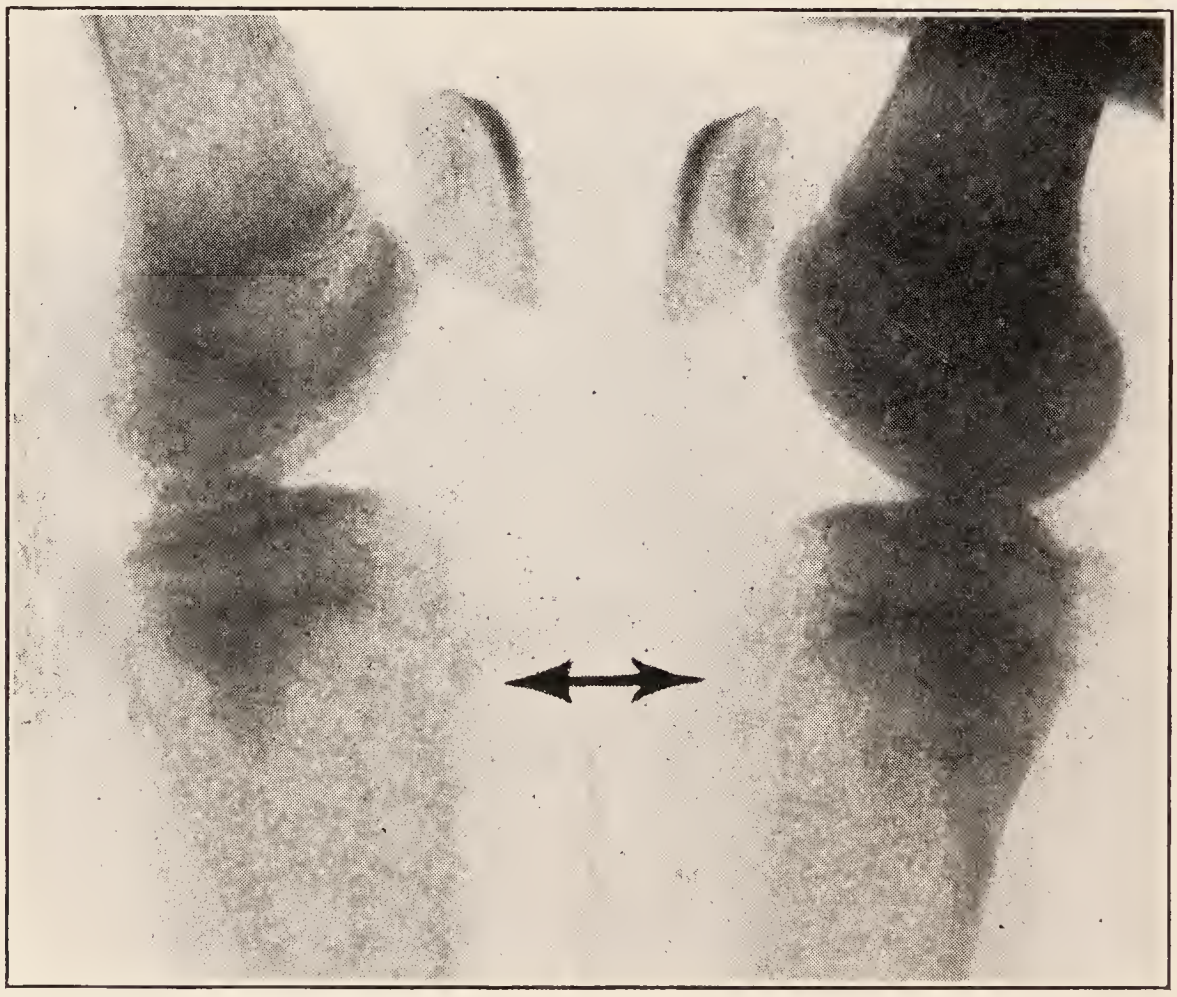


FIG. 364.—Schlatter's disease. Separation of anterior tibial tubercles. (*Courtesy of Doctor Henry Walton.*)

this does not occur, a bone peg may be driven through the tubercle into the bone or it may be sewed in place to the periosteum by sutures of Kangaroo tendon or Chromic Catgut (Fig. 364).

Bursae and Cysts in the Popliteal Region.

Simple inflammation of the bursae between the inner head of the gastrocnemius and the semitendinosus may cause a fluctuating swelling on the inner side of the popliteal region requiring the usual treatment of such conditions, namely, fixation, compression and incision, if necessary.

Genu-recurvatum.

This may be a congenital or an acquired condition, which consists of the knee bending backward instead of forward. In the acquired form, it is due to Infantile Paralysis or Hip Disease or from improperly made traction in which the

gastrocnemius and hamstring muscles are so weakened that backward bending is not opposed. In the congenital form, it is probably due to malposition in the uterus during development and an adaptive shortening of the quadriceps femoris results. This extensive shortening must be overcome by warm baths, massage and stretching. Appropriate splints to prevent backward bending are usually required in both instances to prevent a return of the deformity.

If due to Infantile Paralysis, from involvement of both the gastrocnemius and hamstrings it is sometimes seen in a mild form associated with knock-knee with overaction of the tensor vaginae femoris and biceps. Except when of extreme degree, it may be regarded as nature's effort at stability in the alignment of the femur and tibia and is more stable than a corresponding flexion of an atonic knee (Fig. 365).

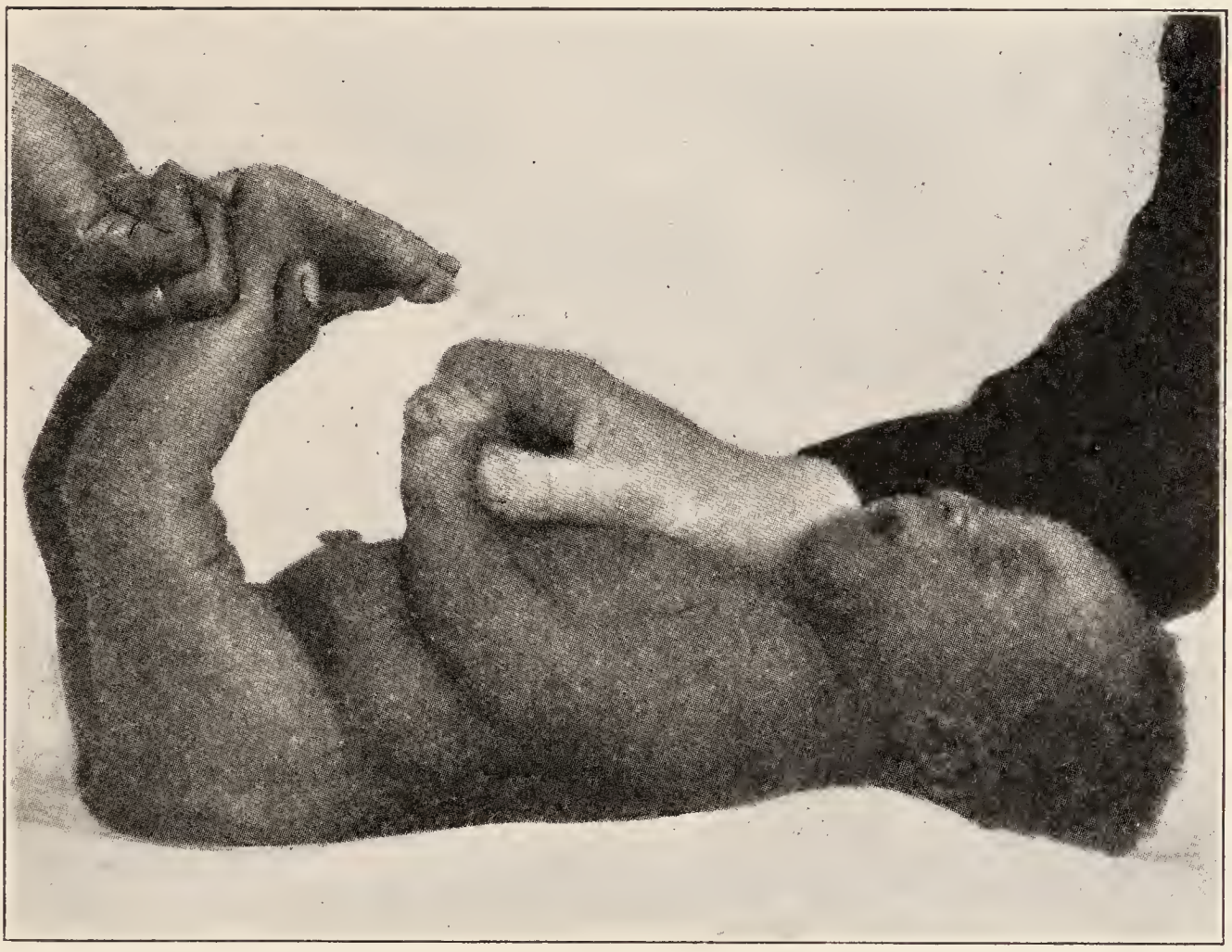


FIG. 365.—Bilateral congenital genu recurvatum. (*Young.*)

Treatment.—The remedy depends upon the cause. In the paralytic, Tendon Transplantation offers but little hope. Supporting braces or Arthrodesis of the knee should be the main reliance. In the variety associated with Knock-Knee, when the Knock-Knee is corrected by an Osteotomy, the backward bending can also be allowed for in over-correcting with a retaining plaster cast in slight flexion. "Back-knee" is sometimes aimed at to stabilize the knee in Infantile Paralysis by arthrodesis of the ankle in slight "foot drop."

Snapping Knee and Slipping Patella.

These conditions are usually associated with an elongation of the quadriceps and ligamentum patellae tendons. Occasionally we see an outward displacement of the patella over the external condyle of the femur. In some instances, associated with destructive changes in the lower end of the femur from tuber-

culosis, we may have this lateral slipping of the patella. Operative relief by the transplantation of the ligamentum patella to another position on the diaphysis of the tibia, or a splitting of the ligamentum patella and attachment of one side to the periosteum of the tibia will afford relief.

Shortening of the Quadriceps Extensor Tendon.

This condition has been described by Bennett[1] and prevents full flexion of the knee. He has devised an ingenious method of lengthening this tendon that affords relief.

Paget's Disease or Osteitis Deformans.

This rare affection is seen in advanced life chiefly in males and leads at first to softening and progressive periosteal thickening and enlargement of the bones,

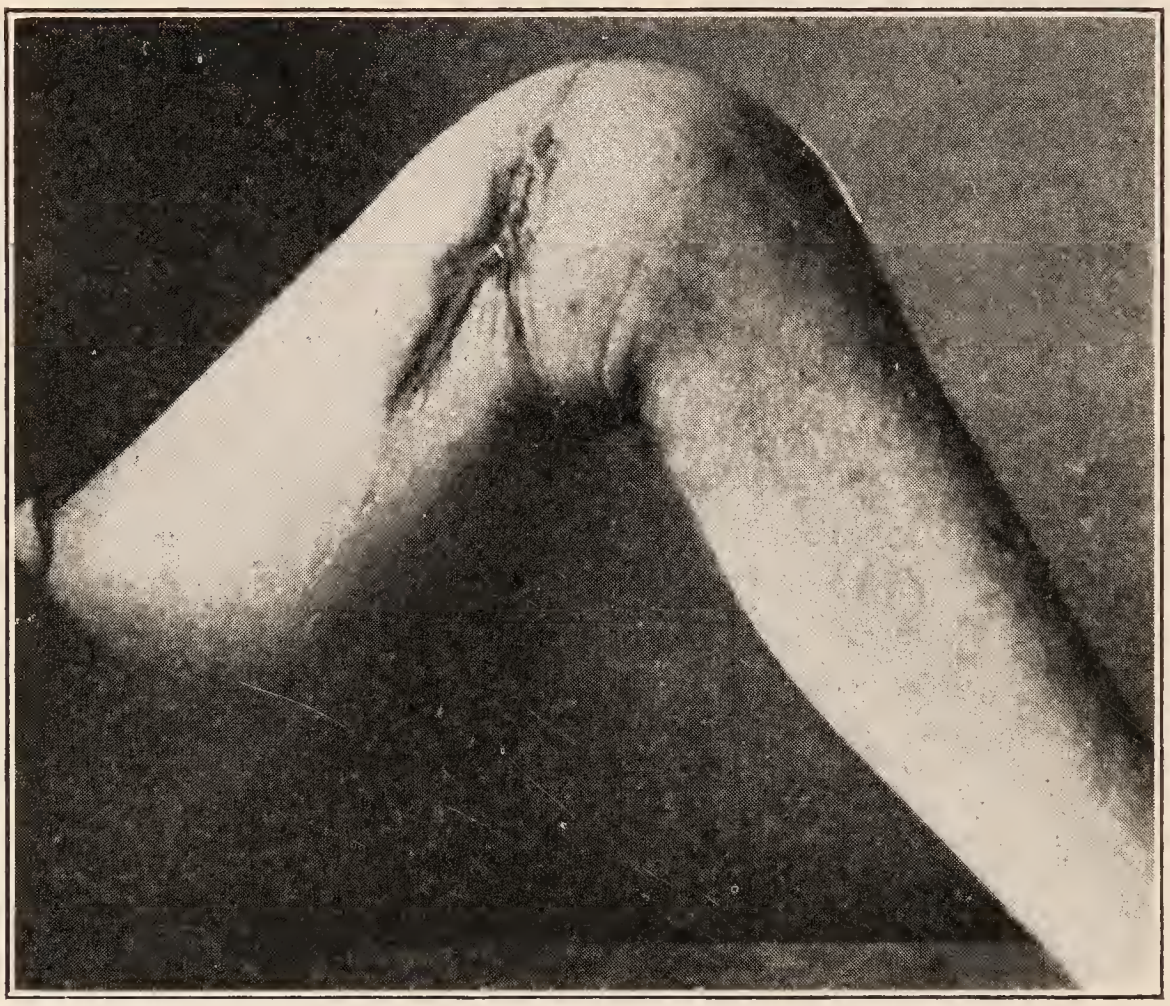


FIG. 366.—Extreme flexion of knee due to osteomyelitis of femur.

bowing of the legs and spine and later extensive deposition of lime salts. Its pathology has recently been carefully worked out by Sydney Cone at the University of Maryland and reported in the Journal of Bone and Joint Diseases.

The treatment consists of suitable supporting steel back- and leg-braces in advanced cases. No remedial drug nor endocrine has been found beneficial in aborting or curing this condition. It is possible that "vitamin D" contained in cod liver oil may be preventive and curative.

Sarcoma of the Knee.

In this condition, not infrequently the lower third of the femur is the seat of malignancy. It is characterized by an onset covering three or four months with the appearance of swelling, which rapidly and progressively increases in size until the affected leg below the new growth is from half again to twice the size

[1] Jour. of Bone and Joint Dis., April, 1920.

of the other leg. This swelling is boggy and doughy in feeling and has points of tenderness chiefly where the new growth has broken through the periosteum. The surface of the skin is rather pallid, although occasionally tortous veins may be seen, if the deep circulation is interfered with. The X-ray picture is dis-



FIG. 367.—Physiotherapy including warm whirlpool baths, massage, active and passive motion in extension or tenotomy of the hamstrings help to correct knee flexion.

similar to an Acute Osteomyelitis in the early stages in that the periosteum is usually thickened and broken through *in all directions* and not in one direction only. There is also calcification of the soft parts in all directions where the deposition of lime forms new bone. Pathological fracture, as shows in the illus-



FIG. 368.—Same as Fig. 366 nearly restored to full extension.

tration is quite frequent, as are metastases in the lungs near the bronchial bifurcations. Metastasis into the liver frequently occurs (Fig. 353).

Diagnosis.—The diagnosis is rendered plain, as a rule, by the absence of very high temperature, which usually characterizes Acute Osteomyelitis. In

Osteo-Sarcoma, the leukocytes may amount to twenty thousand. The haemoglobin in the early stages is not materially affected. On incision, extensive cavernous spaces may be opened up in the small cell variety, which bleed alarmingly. After incision, the temperature may assume the septic variety. The rapid formation of new-bone growth with calcareous deposit is much more rapid than ordinary callus following fracture in repair and should make one suspicious of a malignant new-growth. A pathological specimen, if obtainable, will quickly clear the diagnosis.

Treatment.—Early amputation affords the only possible salvation as radium and the X-ray offer but little hope. Even amputation, which may prove fatal and should be done at the hip joint, prolongs life only for a few months, as a rule. Recently, however, claims have been made that "massive doses" of X-ray therapy have proven helpful. It can do no harm to try them.



FIG. 369.—Tuberculosis of humeral head. General clouding of joint.

Congenital Dislocation of the Knee.

Congenital Dislocation of the Knee occurs in a backward direction from prolonged mal-position in utero. It is recognized at a glance in the new born. The treatment consists of massage and stretching, supplimented by plaster splints or steel braces as may be indicated. This condition usually readily yields to treatment.

Diseases of the Shoulder.

Tubercular Osteitis of the Shoulder.—This is an infrequent condition and is easily recognized by the characteristic family and clinical history that we find present in other joints. Thus it is characterized by muscle spasm, atrophy, swelling and abscess formation. Moderate temperature is present as in other tubercular joints. Pressure and motion produce pain. As the arm is depen-

dent, traction is afforded by its own weight and sole dependence must be made in treatment upon fixation in a cast or in older patients by excision and Arthrodesis by bone-graft or otherwise. The head of the humerus is much more often involved than the glenoid cavity and the synovial membrane. The X-ray will point to the primary lesion. At times the spine of the scapula is involved. The atrophy of the deltoid may suggest to the unwary on first examination a sub-coracoid dislocation (Figs. 369, 370 and 371).

Sub-deltoid Bursitis.

This condition is also called Sub-acromial Bursitis and was first described by Codman.[1] This bursa is situated just below the acromion process lying under



FIG. 370.—Tuberculosis of greater tuberosity of humerus. Removal and cure.

that portion of the deltoid over the joint. It extends about 1½ inches below the greater tuberosity, one-half way around the head of the humerus and is attached to the capsule and bone. Swelling and inflammation of this sac produces pain on pressure, which is a pathognomonic symptom of the condition, on digital examination of this region. Pain is also produced by extension and inward rotation of the arm. This pain is often mistaken for a neuralgia or neuritis from the sharp lightening-like pain referred *down* the arm, even to the fingers.

Etiology.—Trauma and cold play the most important roles in the etiology of this affection.

Diagnosis.—The X-ray gives no information and one must depend on the clinical data cited above.

Treatment.—Rest, heat and massage afford the surest methods of cure. In the hands of the writer the hot-air blast has furnished one of the most produc-

[1] Boston Med. and Surg. Jour., 1906, vol. cliv, page 613.

tive and rapid methods of alleviation. The duration under efficient treatment in the more acute forms should not be over a week or 10 days. In the chronic variety, nothing short of radical excision of the entire sac is of avail, but such radical measures are rarely indicated. The part must be kept warm night and day and painted with crystalized Liniment Petrogen (Wyeth's).



FIG. 371.—Tuberculosis of spine of scapula. Removal and cure.

Obstetrical Paralysis.

This usually manifests itself as a transient paralysis and involvement of the muscles of the shoulder, chiefly the supra- and infra-spinatus, the deltoid and sometimes the supinators of the forearm, as a result of a difficult and prolonged labor. When seen, the cases show as a result of the paralysis of the above-named muscles, an over-action of the pectoralis major and subscapularis. These pull the humerus into extreme inward rotation, so that the infant's elbow projects forward instead of backward, the forearm is in extreme pronation and, as the hand approaches the mouth, the dorsum of the hand instead of the palm presents itself. The arm is held in adduction. If this condition is allowed to persist, great difficulty will be experienced in the use of the hand in eating and other necessary functions in approaching the face (Fig. 372).

Etiology.—The cause is supposed to be a tearing or a partial tearing of the fifth and sixth segments of the brachial plexus, from traction on the head in

instrumental delivery where the shoulder catches on the brim of the pelvis or in shoulder presentations with an after-coming head.

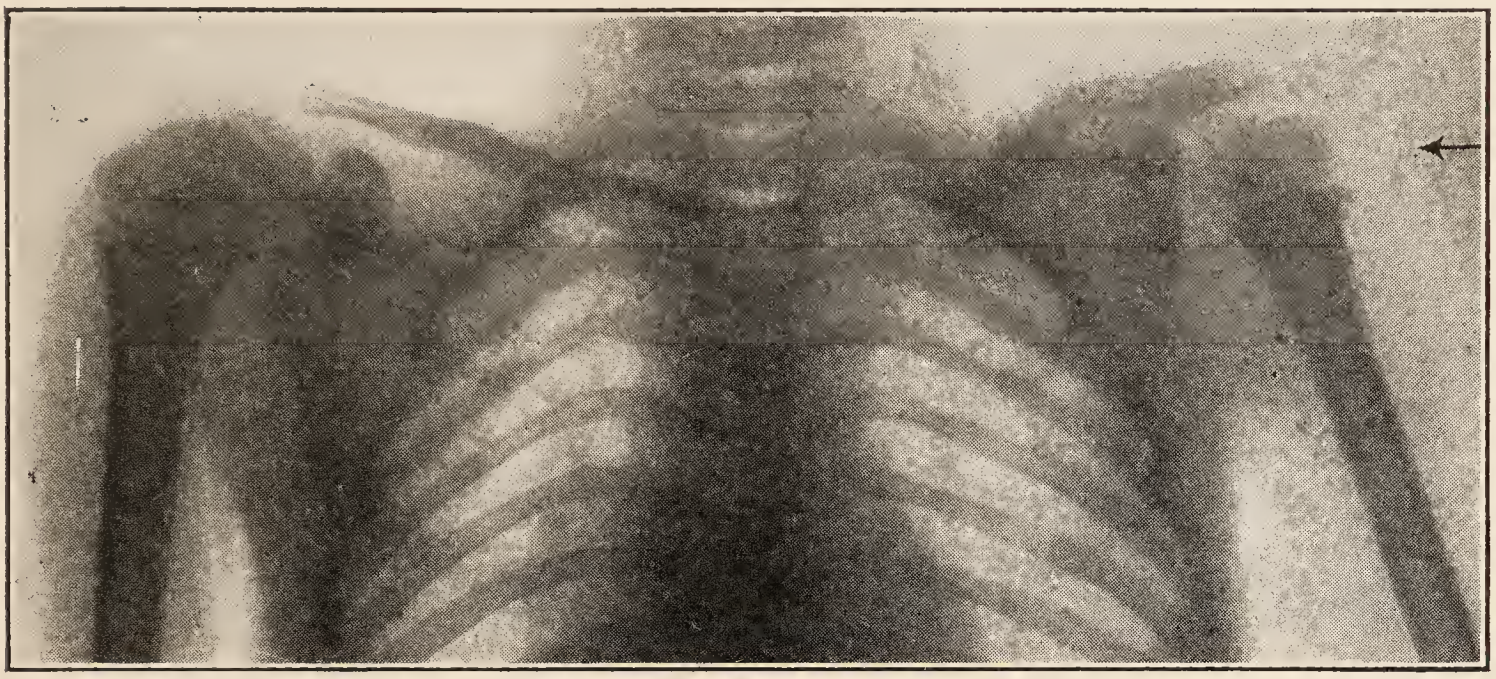


FIG. 372.—Obstetrical paralysis of shoulder (Erb's) showing atrophy of humeral head.



FIG. 373.—Tuberculosis involving all three bones of the elbow (lateral view).

Treatment.—It has been pointed out by many observers that if *promptly treated* by relaxation of all of the paralyzed muscles, that recovery will take

place. Thus, such an infant must have its humerus held by a plaster cast preferably in abduction of 90° and rotated outward a similar amount, so that the forearm points directly up in the air and also held so that it is in extreme supination. This position should be maintained for six weeks or two months or more when a course of massage should be given and stretching applied once or twice daily to the pectorals, sub scapularis and pronators. In older children or adults, it is often necessary to divide the tendons of the sub scapularis and pectoralis major, through a vertical anterior incision down to the bi-cipital groove, where they will be readily found, lifted by a grooved director and incised. After this, the arm is put up in a plaster cast for a month or six weeks in the position



FIG. 374.—Same as Fig. 373 (antero-posterior view).

above described. In addition to the massage and muscle stretching, a course of muscle training should be given to teach the older patients to bring the palm of the hand and not the dorsum to the face. By relaxing the paralyzed muscles for a prolonged period, the ends of the torn nerve are also approximated and it is thought reunion may occur (Fig. 21).

Diseases of the Elbow.

Tubercular Osteitis of the Elbow.—This disease, which is similar in many respects to tubercular diseases in other joints is characterized by pain, local sensitiveness and swelling, muscle spasm, flexion deformity and atrophy. It



FIG. 375.—Fracture of ulna and dislocation of radius.



FIG. 376.—Myositis ossificans. Ankylosis. Common seat of condition after fracture of elbow. Plate inadvertently reversed in making print. Same as Fig. 375 four months later.

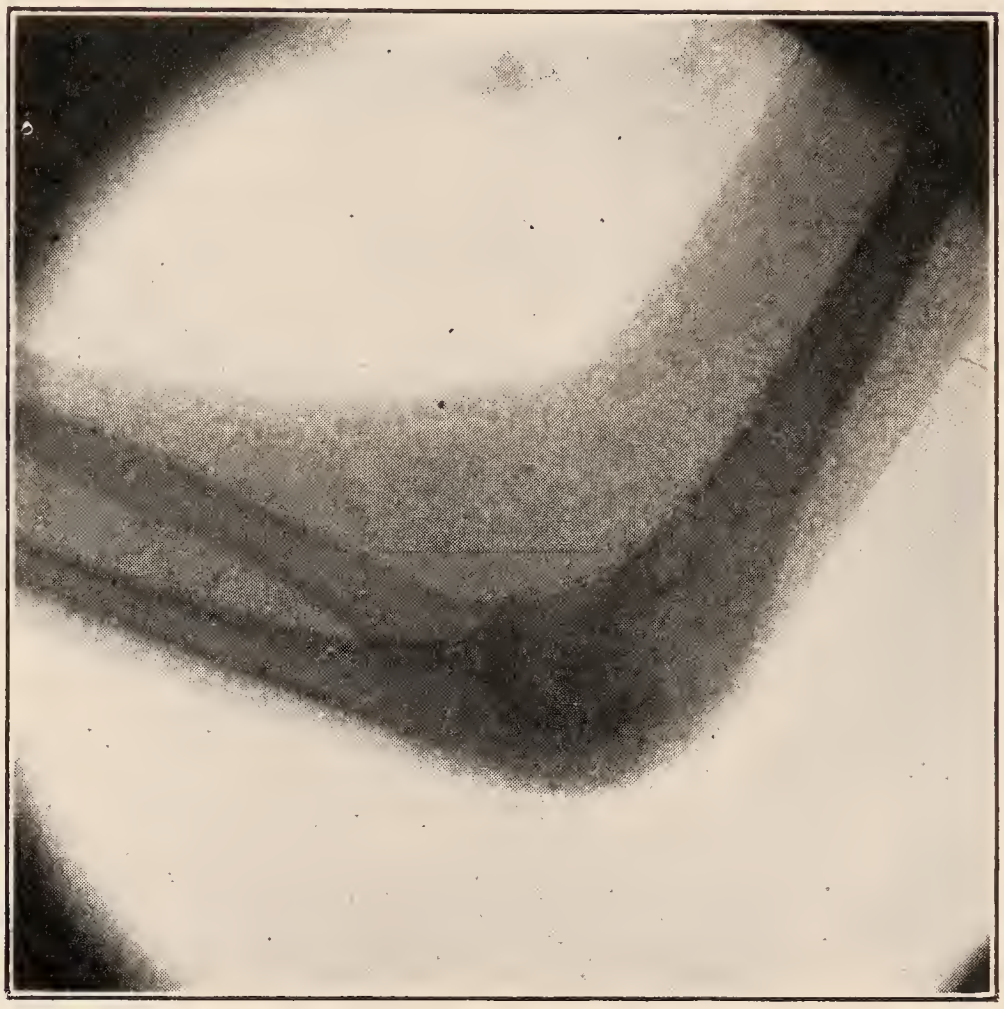


FIG. 377.—Acute infectious osteoarthritis of elbow. (Still's Disease.)



FIG. 378.—Acute osteomyelitis of ulna.



FIG. 379.—Supra-condyloid fracture at elbow.



FIG. 380.—Charcot's elbow. (*Young.*)



FIG. 381.—Early tuberculosis of carpus.



FIG. 382.—Same as Fig. 381. Note swelling of capsule.

occurs next in frequency to tuberculosis of the knee. The humerus and ulna are affected with about equal frequency. Occasionally in very serious cases, we see all three bones involved. The disease is much more common in adults than in children and if the joint becomes ankylosed, the ultimate position has an important occupational bearing, especially if it is the right arm. The X-ray furnishes in addition to the clinical symptoms a ready means of diagnosis (Figs. 373, 374, 375 and 376).



FIG. 383.—Tuberculous tenosynovitis of the wrist with carpal involvement.

Treatment.—The joint in the early stages is readily put at rest by a plaster cast, as the length of the lever on each side makes fixation mechanically quite possible. The position that the arm is placed in the cast should be dependent upon the occupation of the individual. For most occupations, other than husbandry and laborers, the flexed position is the more to be desired. For purposes of eating, writing, shaving and ordinary functions, a flexed position of 100 to 110° of flexion will be found the most useful. In advanced cases, partial resection removing all dead bone will be found, where function is aimed at, to give good results if hygienic and anti-tubercular treatment is available.

In adults, excision and Arthrodesis will give in certain instances quicker cure (Figs. 377, 378, 379 and 380).

Golf and Tennis Elbows.—These conditions occur after over use at these sports, have no definite points of tenderness nor swelling and are probably a dry synovitis. Rest and heat effect cure.

Diseases of the Wrist.

Tubercular Disease of the Wrist Joint.—Tubercular disease usually involves the carpal bones. It may rarely involve the metacarpals or phalanges. If this latter condition is present, it is known as "spina ventosa." The diagnosis is readily made by the X-ray and appears as a clouding or excavation of the bone as seen elsewhere with no new bone formation. The treatment in addition to antitubercular remedies consists in fixation (Figs. 381 and 382).



FIG. 384.—Still's disease or atrophic arthritis of wrists and hands.

Sprain of the Elbow and Wrist.

Diagnosis of sprain of the elbow or sprain of the wrist is readily made, following accident, by local tenderness and loss of function. They are best treated at first by wet compresses of water, Witch Hazel or weak alcoholic solutions together with light splinting. When the torn ligament is identified, compression by a pad of adhesive or felt should be made at the point of tear and intelligently applied vertical and horizontal strapping for support and approximation, care being observed that the latter do not constrict the circulation.

Acute and Tubercular Tenosynovitis of the Wrist.

These are not unusual conditions to be met with. They are chiefly on the dorsum of the hand. The former is accompanied by a creaking sensation when



FIG. 385.—Rheumatoid arthritis or hypertrophic arthritis involving carpus, metacarpus and phalanges in bony overgrowths.

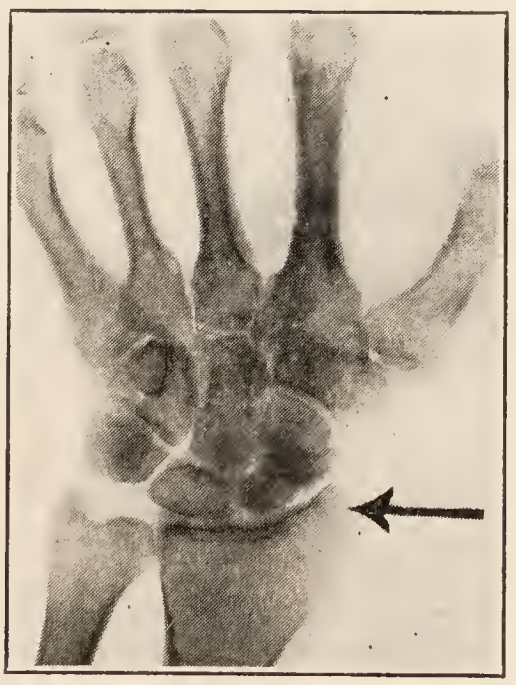


FIG. 386.—Fracture of scaphoid a common and often overlooked wrist injury.

the part is moved and the affected tendon sheath is palpated. The X-ray of the acute variety is characterized by an absence of the characteristic bone changes seen in hypertrophic arthritis, but there is an unusual thickening of the tendon sheath.

Acute Tenosynovitis can well be treated by adhesive strapping and slight splinting. The tubercular variety usually calls for the application of a plaster cast and prolonged rest. The latter is not infrequently associated with tuberculosis of the carpus, as seen in the X-ray. Incision short of extreme resection is followed by chronic sinus formation (Fig. 383).



FIG. 387.—Tuberculosis involving astragalus, scaphoid and other tarsal bones.

Diseases of the Ankle.

Tuberculosis of the Ankle.—This disease occurs next in frequency to tuberculosis in the elbow. The tarsus is more often involved than the tibio-astragaloid joint. Muscle spasm and atrophy together with insidious onset following trauma characterize the condition. Talipes Equinus is the usual position from contracture of calf muscles (Figs. 387, 388, 389, 390 and 391).

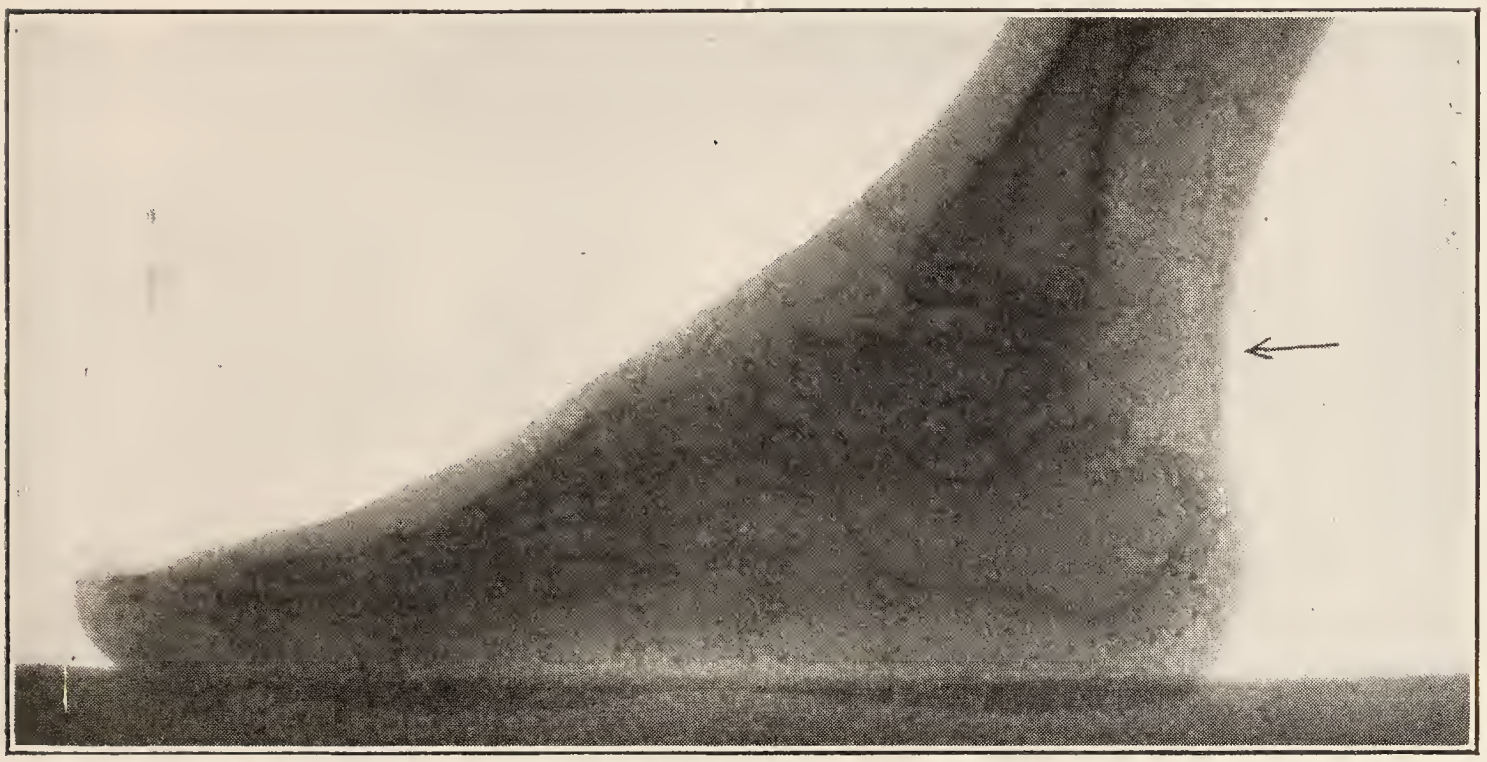


FIG. 388.—Tuberculosis of tibio-astragaloid joint nearly healed.



FIG. 389.—Osteo-arthritis of ankle with "lipping" or marginal overgrowths in medio-tarsal region.



FIG. 390.—Osteomyelitis of tibia producing swelling and muscle spasm at ankle. Diagnosis plain from X-ray.



FIG. 391.—Charcot's ankle. Old luetic history. (*Young.*)

CHAPTER XX

BOW-LEGS, KNOCK-KNEE AND ANTERIOR BOWING OF THE TIBIA

The curvatures in the leg bones most commonly seen are Bow-leg and Knock-Knee, the former spoken of descriptively by the Germans as O-Bein or Sichel-Bein and by the French as Genu en Dehors and the latter as, X-Bein or Knick Bein of the Germans and Genu en dans of the French. However, occasionally in clinics Forward Curvatures in the Tibiae or Anterior Curvatures are seen at the junction of the middle- and lower-thirds or even lower.

Synonyms.

Genu Varum—Bow-legs. Genu Valgum—Knock-knees.

Preventive Measures.

These deformities are practically always evidences of rachitic softening and distortion from posture during the acute stage. The younger the child with rickets, the more easily can deformity be prevented avoiding bone pressure, strain, weight-bearing and gravity, by recumbency on a Bradford frame. This is naturally of great importance as a means of treatment of spinal curvatures as well as distortions of the limbs.

Limitations of Mechanical and Operative Treatment.

When rickets has passed to the stage of eburnation in infants, usually when about 2½ to 3 years of age, preventive treatment and for the matter of that, mechanical or brace treatment is of little value and at best is a slow method of correction. After four years the operative method is the treatment of choice and in well established deformity is the treatment of choice in all ages in the writer's opinion, owing to the simplicity of the operative procedures and their comparative safety unless such complications as Cyclic Vomiting, Acetonuria, Laryngeal Spasm, Hypertrophied Tonsils and Bronchitis exist, which should be straightened out, before operative correction of the deformity is undertaken under a general anaesthetic. Spinal anaesthesia is not as applicable to little children from their natural timidity and fear as it is in adults.

Prevalence and Permanency of Rachitic Deformities.

It is often maintained especially with regard to Bow-Legs that the child will outgrow the distortion. This, however, is by no means the general rule, if one can judge by the number of cases seen among adults. During the recent prevalence of the vogue for short skirts, one could not help noting the number of bow-legged women seen. The concealment afforded by the long skirt later in life is probably the explanation of the lesser number of girl-patients brought by parents to Orthopaedic Clinics than boys, the latter being about one-third greater. There is no actual reason for a greater incidence in either sex.

Of the two deformities, Knock-knee, leading to "interference" or actual knocking of the knees together in progression or awkward swinging of one leg around the other, is the more serious, as many of us have seen exceedingly good athletes, runners, foot-ball and base-ball players, who were bowlegged and functionally strong and efficient. This is not so with Knock-Knees.



FIG. 392.—Bow-legs; chief curvature at junction of lower and middle third of tibiae and fibulae.



FIG. 393.—Knock-knee with pronation and talipes varus in feet.



FIG. 394.—Marked knock-knee and interference chiefly due to chief curvature in right tibia and fibula. Pronation and flat-feet.



FIG. 395.—Knock-knee chiefly from femoral curve.

Definition of Bow-leg and Knock-knee.

Women, with wider pelves than men normally, have a greater inclination of the femora downward and inward or if we may use the term, are morphologically knock-kneed. This term, Knock-knee, however, signifies more than a simple downward and inward inclination from the hip joint, but rather an angulation of the femur with the tibia, obtusely outward, so that a line from the femoral head to the centre of the tibio-astragaloid joint will pass external to the patella or the knee joint itself and not bisect it as it should. Conversely, a Bow-leg is one in which if a line is drawn from the femoral head to the centre of the ankle,

the leg will be curved outside of such a line. The deformity of Knock-knee consists of a bending in either the femur or tibia near the knee and usually the femur is to blame, whereas Bow-leg is more often in the lower third of the tibia, but may involve all of the tibia and fibula and femur as well.

Frequency.

At clinics, Bow-legs are seen nearly twice as often as Knock-knees and Anterior Bowing of the Tibia in our clinics occurs in about one in ten. The latter is associated with Bow-legs and is usually found in negro children (Fig. 396).



FIG. 396.—Anterior bowing of the tibiae or "sabre legs."

Vitamin D.

Rickets itself must be cared for medically as well as surgically, especially in cases seen at an early stage of deformities from this disease. The recent splendid experimental work in feeding done by McCollum, Simonds and Shipley at the Johns Hopkins Hospital has isolated Vitamins A, B, C and D and has also shown us that changes or departures from normal in calcium or phosphorus metabolism or an abnormal relationship in these elements in a ration will produce Rickets from absence of Vitamin D.

When there is a disproportion between these elements, the calcium supply being inadequate and the phosphorus abundant or the phosphorus supply inadequate and the calcium abundant or excessive, this disease is likely to develop. Thus, there are two types, calcium inadequacy and phosphorus inadequacy.

In the studies on dietetics by these investigators and Mellanby of England, it has been found that certain food deficiencies produce an opthalmia and cod liver oil and certain other fats furnish a protective element or as it is called, Vitamin A, which cures this eye trouble. If, however, this fat is oxidized, it no longer possesses this corrective action of the ophthalmia, but still possesses the power to correct and cure Rickets. This last element in fats is designated as Vitamin D. Thus we find such oils, as cod liver oil, contain both Vitamins A and D. Deficiency in Vitamin B bears a causative relation to certain paralyses and Vitamin C to scurvy. In addition to giving a proper diet, cod liver oil is practically a specific in preventing and curing Rickets. Of course, cod

liver oil has been used in this disease empirically for generations, but its action was not understood. Fresh air, cold sponging, contrast baths, sun-light and prolonged incandescent electric light baths and regulated diet have helped restore a proper metabolism as shown in the reports of many clinicians.

Operative Treatment of Bow-legs.

Immediate correction of rachitic deformities of the lower extremities by either manual or mechanical straightening in the stage of softening, or osteoclasis or osteotomy in the stage of eburnation are the methods that should be employed[1] (Figs. 62 and 63).

In 109 consecutive cases at the Kernan Hospital for Crippled Children, in the following deformities, Genu Valgum 42, Genu Varum 59, and Anterior Bowing of the Tibia 8, we have operated with only two relapses and one over-correction (a Genu Valgum complicating a Genu Varum, requiring a secondary operation to obtain satisfactory results).

We have not discriminated, as is usually done, and put braces on the very young with flexible bones, but simply under ether straightened these legs manually or instrumentally, used fixation in plaster in slight over-correction for four to six weeks, and instituted proper feeding, cod liver oil, good hygiene and fixation on a Bradford frame, until all symptoms of the so-called "Acute Rickets" are passed, as shown by the absence of the usual manifestations and the restored presence of improved nutrition.

In only two cases in this series were braces employed and these were not satisfactory in the results obtained (Fig. 84).

My reasons for holding these views are: First, when we take into consideration the primary cost of braces to this class of cases, which we find among the negroes, Italians and poorer classes of Americans in our dispensaries, as a rule, we must needs feel that any immediate correction of the deformity which will obviate the expense of braces is desirable. Second, braces usually have to be worn for a year or more by children under three to effect a cure. Bow-leg braces coming down the inner side of the leg are apt to trip the child and cause a fracture of the arm or elsewhere. Braces are usually entirely useless on eburnated bones after the fourth year. Third, the objection raised by one of my New York friends, that they "could not habitually operate on Bow-legs and Knock-knees there, because the parents would not consent and "they had seen other children with suitable braces for the deformity,'" we meet, *not* by suggesting "*an operation* to *break* the legs," but by "a suggestion that we give the child a little gas and bend the legs straight," which we do often then and there. Seldom are we refused, especially when we tell them that the child's legs will have to be held straight in plaster of paris for four to six weeks and will require nothing later to keep the deformity from returning. Fourth, the danger of these operations needs not deter us in the slightest degree with modern asepsis (I speak of Osteotomy) from resorting to the operative method. Osteoclasis for Genu Varum is one of our simplest and most harmless procedures, even standing ahead of Tenotomy of the tendo Achillis in its simplicity (Fig. 397).

[1] R. T. Taylor "The Mechanical vs. the Operative Treatment of Rachitic Deformities of the Lower Extremities, Presenting a New Osteoclast," Jour. of Ortho. Surg., Aug., 1903, vol. 1, No. 1.

We have not infrequently sent home the same day that the operation was done in the dispensary, not only the cases of Genu Varum after Osteoclasis, but Genu Valgum also.

With plenty of padding under the cast, especially at the seat of the fracture and between the toes, these patients have little or no discomfort, except from the restraint offered by the plaster, and are cured by the time the braces, had they been ordered, would have come from the instrument-maker and been properly adjusted to be worn in the daytime (Figs. 398, 400 and 401).

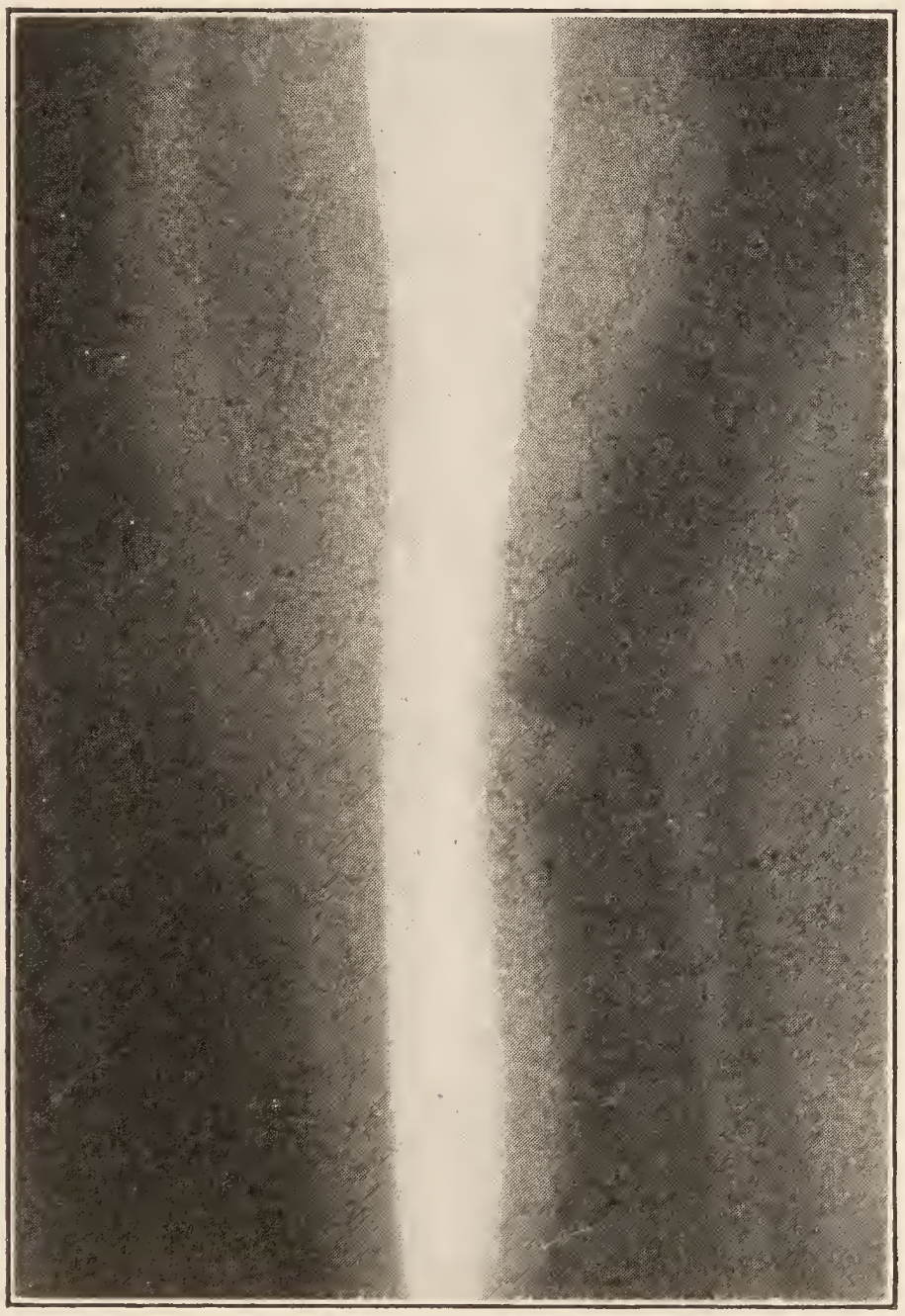


FIG. 397.—X-ray showing linear fracture of tibia after osteoclasis.

In addition, spring night braces with foot pieces or split plaster casts, remade at short intervals, as progress occurs, should be worn.

The comparison of the length of time the child has to submit to the discomfort of the plaster bandages after an operation versus the use of braces is wholly in favor of the operative method.

I have devised a new osteoclast on the lever principle instead of the screw, as seen in Rizzoli's, Grattan's, Colin's and Lorenz's osteoclasts (Figs. 62 and 63).

The Author's Osteoclast.

It consists of a T-shaped base, the arms of the T being some 12 inches wide and the stem some 36 inches long. Arising from the intersection of

the arms and on the stem is an arc some 12 inches high at its summit and 12 inches wide at its base (Figs. 62 and 63).

Some three inches above and parallel with the stem of the base is a movable half-inch square rod which may slide backward and forward through slots in the arc. From the summit of the arc depends the short arm of the lever some nine inches down to its attachment to the movable rod. The long arm of the lever extends backward at a right angle to the short arm some 24 inches.

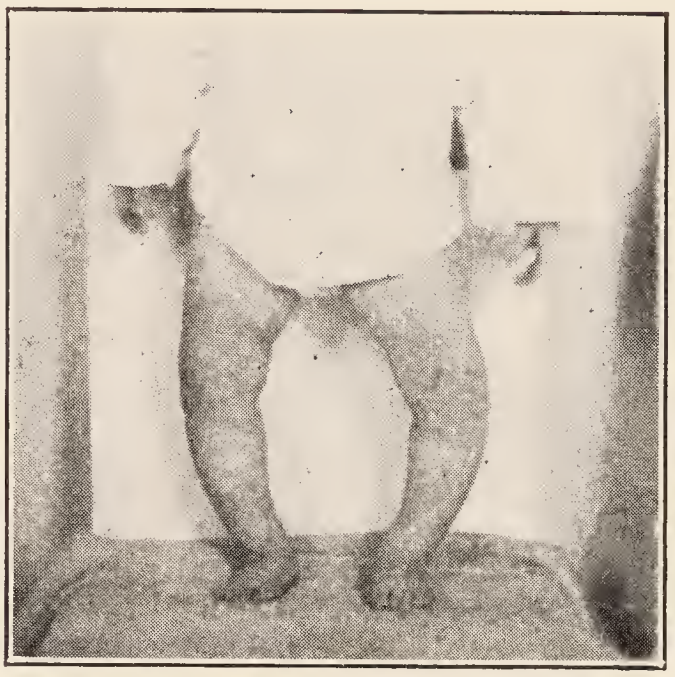


FIG. 398.—Bow-legs involving both upper and lower legs.

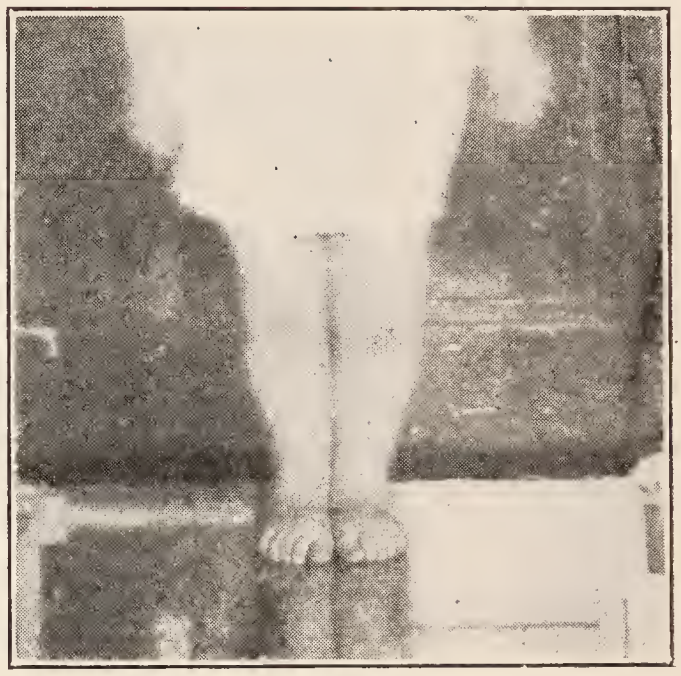


FIG. 399.—Same case as Fig. 398 two months after osteoclasis.

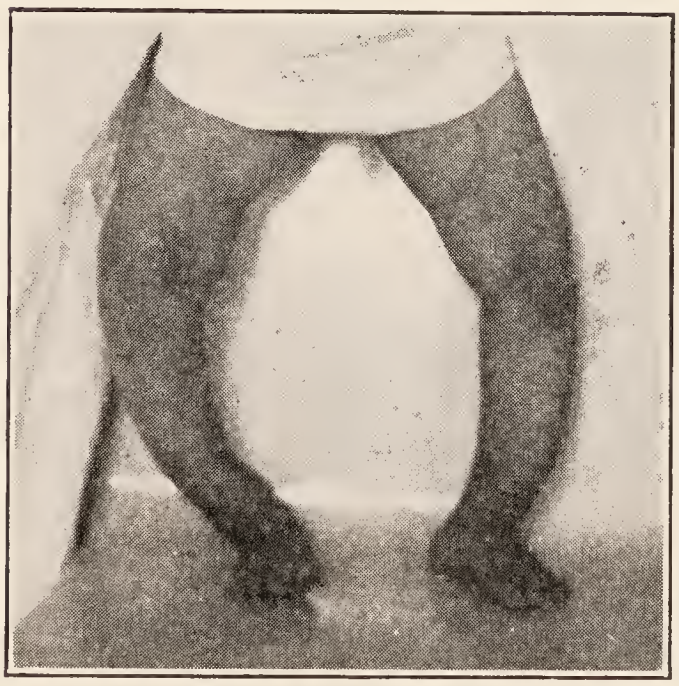


FIG. 400.—Bow-legs involving thighs and lower legs.



FIG. 401.—Same as Fig. 400 one year after osteoclasis.

It is fastened at the top of the arch by a bolt allowing free play around this axis. Its attachment to the movable rod is by means of a notch, to receive the rod, an inch by one-fourth of an inch slot on the sides, through which may pass and play a pin into one of a series of holes which can be used to regulate the length of the movable rod beyond the top of the T. On the end of the rod is attached, by a swivel joint, a pressure plate to afford the thrust at the apex of the curve in the bone.

Two C-shaped arcs of the usual type are attached and regulated, by set-screws on the arms of the T, for children of different length of bone. For adjustment to legs of varying circumferences and elasticity of bone, the pin through the slot can be adjusted, so that, when the lever is pressed down after the leg has been placed against the C-pieces, the forward thrust of the movable rod may be extreme or slight. For Genu Valgum both C-pieces may be put on one side.

The advantages claimed for this device are the immediate fracture and release, which cannot be obtained with the other osteoclasts. It usually requires not more than 10 to 20 minutes to give the anaesthetic, fracture the bones and complete the casts on both legs. The fracture is linear and extends about three-fourths through the bone, a hinge being left which maintains apposition. The casts for Bow-legs in the tibia and fibula need not extend above the groins. Fractures of the femora must, however, have spicas applied to the foot, extend up and include the pelvis and cover the lower ribs for comfort and fixation. The author's Osteoclast is readily taken apart for carrying in a suitcase. In adults, an Osteotomy is usually the operation of choice rather than Osteoclasis on account of the hardness and unyielding nature of their bones to Osteoclasis. The section is either linear or by cuneiform section at the apex of curvature depending on the severity of the case .

The reader is referred to Chapter X and the section there on Osteoclasis and Osteotomy.

Mechanical Treatment of Bow-legs.

In the early stages of Rickets when Bow-legs have occurred in very young children prior to 2½ years of age, in cases where parents will not consent to an operation or when some intercurrent disease prevents the use of an anaesthetic, one is justified in using braces. Two types of braces are usually employed. The first, to pull the curvature in, consists of a steel sole plate with ankle joint and a vertical upright extending to a pad or band in the region of the groin. At the point of maximum curvature, a leather cuff and straps extend around the outside of the bone and pull the curvature in an inward direction. Most children with Bow-legs are also extremely pigeon-toed. This can be corrected at the same time by having the thigh band extend across the front of the thigh to the region of the anterior-superior spines, where a buckle is placed on the steel thigh band. By means of tightening the strap from this buckle, which passes around the back of the pelvis, one can produce the amount of eversion desired. If a steel sole plate is used, this type of brace can be used as a night brace, as well as worn inside the shoe for use in the day time. In the second or the other type, correction may be also produced in certain cases by pressure. It consists of a concave spring steel brace with a pressure pad and maximum curvature at the point of deformity. On the ends of this brace, leather cuffs are attached, which surround the ankle, foot and thigh. If the type of inside uprights is used, the child is very apt to trip and possibly injure itself. If the type of brace is used which is attached to the shoe, resource must be made to plaster casts put on at frequent intervals to take up the gain made by the steel brace. These plaster casts are cut down the back, so that they can be readily removed and replaced as desired, at night.

Changes in Cortex of Bone.

The students of Bow-Legs and Knock-Knees should familiarize themselves with the X-ray appearances of longitudinal transverse sections of these bones to appreciate the changes that were pointed out by Julius Wolff in establishing Wolff's Law. One will note that that portion of the bone, which is subjected to the greater strain is much thickened in order to stand this strain and conversely, the opposite side is thinner than normal. Therefore, after fracture, the deformity must be over-corrected, so that the convex side of the bone will stand the greater strain, undergo an adaptive thickening and re-establish an equal thickness on the lateral and medial side of the bone. Thus, in bow-legs, we find the cortex much thickened on the inner side and in knock-knees on the outer side to meet new demands of "pathological function" (Figs. 98 and 99).

Operative Treatment of Knock-knees.

A study of the majority of the cases of Knock-knee shows usually a bending of the diaphysis above the knee-joint in the femur. The earlier writers and observers considered that there was an over-growth of the inner condyle or inner side of the epiphysis of the femur, but this is purely relative and due to bending in the diaphysis, so that operative section into the joint, cutting the internal condyle free, as recommended by Ogston and Reeves and sliding this internal condyle up to straighten the leg, is not strictly scientific and may lead to limitation of motion or actual ankylosis in the knee joint. In small children this procedure may seriously impair the growth of the femur also, on that side.

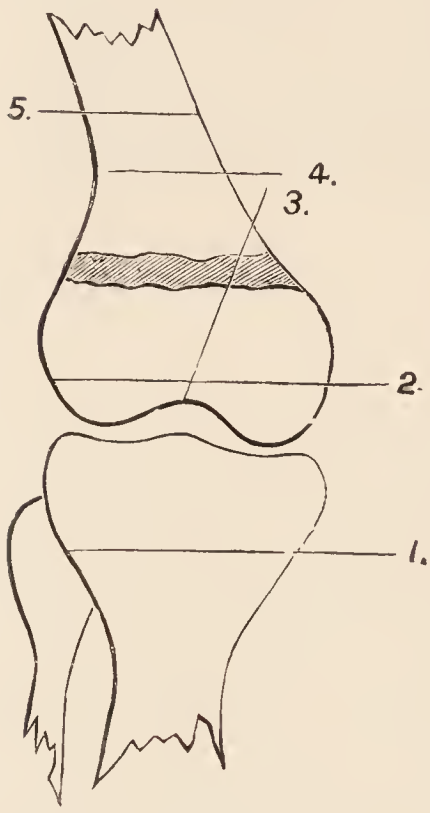


FIG. 402.—Lines for osteotomy. (*Young.*)

1, Mayer, Bollroth, Schede; 2, Annandale; 3, Ogston, Reeves, Chieve; 4, MacEwen, MacCormac; 5, Sayre, Taylor.

Ogston performed this operation with a saw and Reeves suggested the use of a chisel or Osteotome. Passing to the other extreme, Charles Fayette Taylor and Sayre suggested dividing the diaphysis of the femur well up above the adductor tubercle, whereas Billroth, Mayer and Schede suggested division of the tibia and fibula in a transverse direction just below the joint.

The operations generally accepted now by the majority of American Surgeons are the MacEwen and MacCormac Osteotomies (Fig. 402).

The MacEwen Osteotomy.—The Macewen Osteotomy consists of cutting the femur transversely three-quarters of the way across, one finger breadth above the adductor tubercle. After this section, the leg is fully extended at the knee and fracture is made outward in the direction of the deformity. After fracture, impaction of the two fragments is done, the wound covered with silver foil and gauze, and the leg is put up in over-correction in plaster of paris. In order to maintain this over-correction while the plaster is setting, a three-inch gauze bandage is placed endwise between the two knees and held in place by an additional turn of plaster bandage. It is needless to say that these cases must have spicas extending from the tips of the toes well up above the pelvis (Fig. 67).

The MacCormac Osteotomy.—The MacCormac operation is identical with the Macewen, except the bone is divided from the outer side and the fracture is made in an inward direction or the direction contrary to the deformity. When fracture occurs an appreciable triangular space is left on the outer side between the two fragments. Thus, the MacCormac operation slightly lengthens the leg, when this gap fills in with callus and bone, whereas the impaction incident to the Macewen procedure tends to shorten it slightly. It is needless to say that the strictest asepsis is essential in both of these procedures and if observed, one



FIG. 403.—Bow-legged in left leg, knock-knee in right.



FIG. 404.—Same as Fig. 403 (back view).



FIG. 405.—Same as Fig. 403 after osteotomy in right and osteoclasis in left leg.

with moderate skill, need have no serious apprehension as to the end result (Figs. 403, 404 and 405).

The Mechanical Treatment of Knock-knees.

The principles brought to bear upon the construction of braces for Bow-Legs holds equally in Knock-Knees. The simplest brace is one that extends from a pelvic band to the ankle joint of the shoe or to a steel foot plate with a leather pad to pull the knee by means of straps towards this vertical rod. The spring

type of brace has its convexity outward in the region of the knee joint where there is a leather and felt pressure pad. At the upper and lower end there are leather cuffs, which when applied to the thigh and foot cause the maximum pressure to be exerted in an outward direction at the knee. In other words, one is a pull brace and the other is a push brace. Plaster casts are made while the deformity is manually corrected for night wear in Knock-Knees, as well as in Bow-Legs (Fig. 84).

Operative Treatment of Anterior Bowing of the Tibia.

These cases not only have an anterior bowing of the tibia usually at the junction of the middle and lower third, but these bones are often flattened very much from side to side and are often spoken of as sabre-shaped or sickle-shaped bones, presenting a sharp, anterior edge, much sharper than the usual crest of the tibia. The use of a leather strap to pull this curvature backward to two lateral uprights on a brace more often than not causes sloughing of the skin in the region of the curve. Therefore, the operative treatment is the only one that offers us a reasonable chance for correction. As a guide, preliminary to the operation as to how much bone of a cuneiform shape should be removed, it is well for the operator to use a piece of lead tape to mold along the skin and use this as a ruler on a piece of paper, which we then cut out with a pair of scissors, nick a cut in the apex and overlap the two a sufficient amount to convert the curve into an approximately straight line. The operator will then have a guide as to the width of the wedge that he should remove, which having been done, the leg is put up in over-correction in a plaster of paris bandage to the mid-thigh.

CHAPTER XXI

DEFORMITIES OF THE FOOT

Definition.

A definition of foot deformity may be given as either a changed relationship in the normal position that adjacent component bones bear to each other or limitation of motion in normal function or both. There may also be foot disabilities without deformity such as foot-strain, weak-foot and the like and deformity without disability or loss of function as in Congenital or Racial Flat Foot in the negro and Jew.

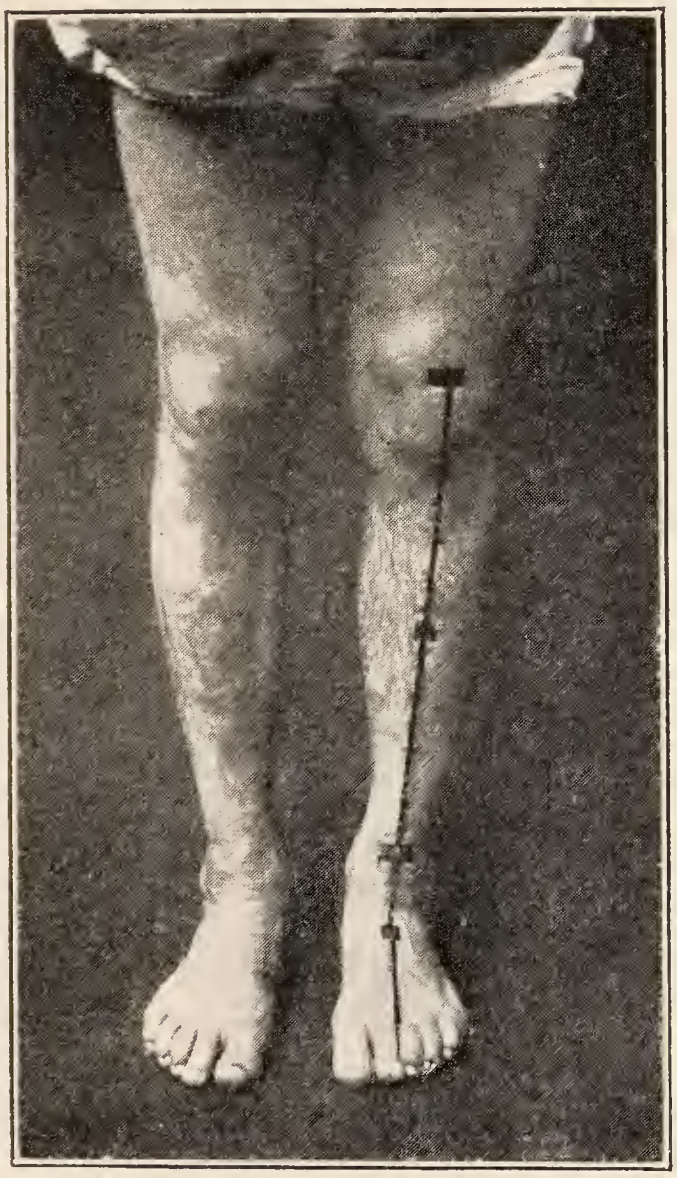


FIG. 406.

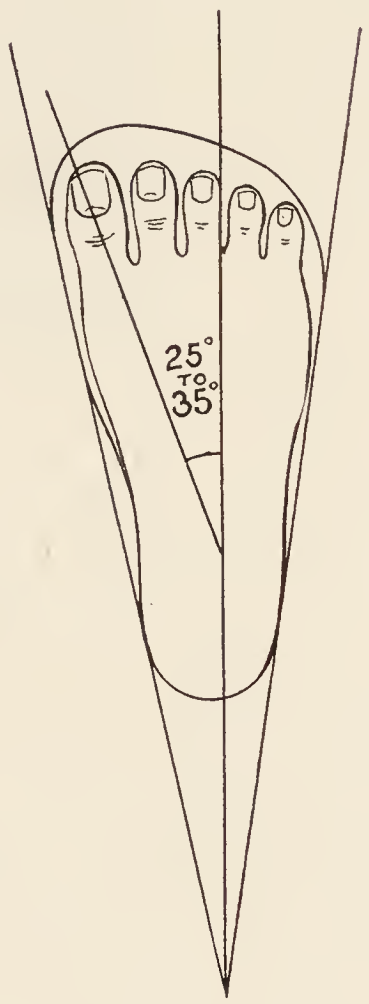


FIG. 407.

FIG. 406.—Normal weight bearing line from patella, through shin and ankle to the third toe.

FIG. 407.—Normal long axis of foot bisects the os calcis and projected forward passes through the third toe. The heel tends to a point and not the toes. A line from the medio-tarsal joint where it is crossed by the long axis line, to the tip of great toe, shows a deflection inward of 25 to 35 degrees, which should be present in anatomical shoes.

Anatomy.

From the standpoint of deformity or deviation from the normal, the foot and ankle joint including the leg have to be considered together. Normally, a line drawn from the patella vertically down the crest of the tibia should pass through the third toe (Fig. 406).

One may also regard a line joining the middle toe and the centre of the tuberosity of the os calcis (tuber calcanei) as the long axis of the foot around which pathological rotation may occur (Fig. 407).

Antero-posterior Arch.

Normally the foot is at a right angle with the leg, a position peculiar to man, and is an arch supported on three piers namely the tubercles of the os calcis posteriorly and anteriorly by the heads of the first and fifth metatarsal bones. This arch is known as the *Antero-Posterior* or *Longitudinal Arch* and is composed of two segments, each, however, having the os calcis in common posteriorly (Fig. 408).



Fig. 408.—Medial view showing normal arch resting on piers of great toe and os calcis.

Thus, the inner segment is composed of the os calcis, astragalus, scaphoid, three cuneiform bones, their metatarsals and phalanges: whereas the outer is composed of the os calcis, cuboid, two outer metatarsals and their phalanges. Of these two segments, the inner forms the higher arch and in the normal foot, the phalanges should be on straight lines as prolongations of their respective metatarsals; this last, however, is rarely found in adults from the distortion produced by prolonged wearing of non-anatomical or unhygienic shoes. The longitudinal arch will also be seen in the skeleton to consist of two limbs, a posterior limb consisting of the os calcis and astragalus about three inches long and an anterior limb consists of the rest of the tarsal and metatarsal bones and phalanges and is about seven inches long.

The highest point and weakest part of the longitudinal arch is at the articulation of the astragulus and scaphoid, which is braced by strong ligaments and muscles. Of these the more important are "the inferior Calcaneo-scaphoid ligament," which is more elastic than most other ligaments and thus allows the arch to yield from jars or shocks applied to the anterior portion of the foot and quickly restores it to its pristine condition. This ligament is supported internally by blending with the deltoid ligament from the ankle joint and by the fan-shaped insertion of the tibialis posticus muscle. In addition to small intrinsic ligaments between adjacent bones, the tibialis anticus and peroneus longus muscles contribute largely to prevent the overstretching of the ligaments and

maintenance of the symmetry of the foot, when subjected to strain. Sensory nerves are in the periosteum to which the ligaments are attached. Muscle fatigue produces therefore ligamentous strain and strain produces pain.

Transverse Arch.

In addition to the longitudinal arch there is a transverse arch extending across the foot from the heads of the metatarsals to the mid-tarsal region at the scaphoid.

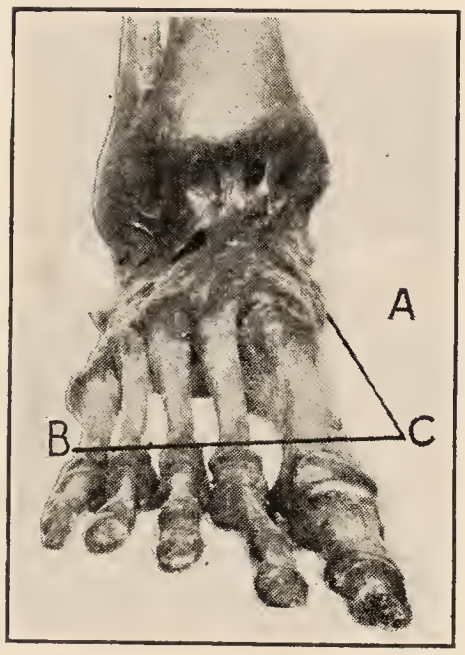


FIG. 409.—Transverse arch. Highest point at A, the scaphoid.



FIG. 410.—Normal foot, superior view; straight medial side; toes in line with metatarsals; note wider cleft between first and second toes.



FIG. 411.—Normal foot, anterior view, straight medial side from heel to terminal phalanx of great toe, as shown by ruler. Straight toes as in Fig. 410.

The antero-posterior and transverse arches are maintained not only by the ligaments but by the plantar fascia, interossei, short flexors, peronei, longus, brevis and tertius, tibialis anticus and posticus muscles and to a certain extent by the abductor pollicis and abductor minimi digiti (Figs. 409, 410 and 411).

Normal Angle of Deflection.

If a line is projected forward from the centre of the os calcis in the normal foot, it will be found to go through the middle toe. If, at the point, this line passes through the *medio-tarsal joint* (or the articulation between the scaphoid and astragalus and between the cuboid and os calcis) a second line is projected forward through the ball of the great toe, the angle formed by these two lines will be from 25 to 35° in normal limits. This angle is spoken of as the "Normal Angle of Deflection," that is the fore-foot is *adducted* with relation to the heel 25 to 35° normally (Figs. 412 and 413).



FIG. 412.—Normal angle of deflection. In this cut the long axis passes through cleft between 3d and 4th toes, but is usually described as passing through 3d toe.



FIG. 413.—Abducted fore-foot and deviated (abducted) great-toe and other phalanges resulting from improper shoes.

Abduction and Adduction.

If the fore-foot is deflected at the medio-tarsal joint in an outward direction and this angle is lessened, we say the foot *is abducted* and constitutes *Talipes Valgus or Flat-foot.* If, on the other hand, the normal angle is increased and the foot is more *adducted* than normal, we speak of this as *Talipes Varus* or Club-foot.

Many regard the fore-foot in the normal individual as straight in front of the heel, whereas as a matter of fact it is twisted or turned in at the medio-tarsal joint at quite an appreciable angle and it is at this joint, motions of abduction and adduction take place in maintaining equilibrium and balance from inequalities on the ground (Figs. 414 and 415).

At the ankle joint, on the other hand, the motions are chiefly of flexion and extension.

Only when the foot is in extreme extension in relation to the leg is there a slight amount of abduction or adduction at the ankle joint, for the superior articular surface of the astragalus becomes narrower posteriorly and fits less snugly between the malleoli, when carried forward by the extension of the foot on the leg.

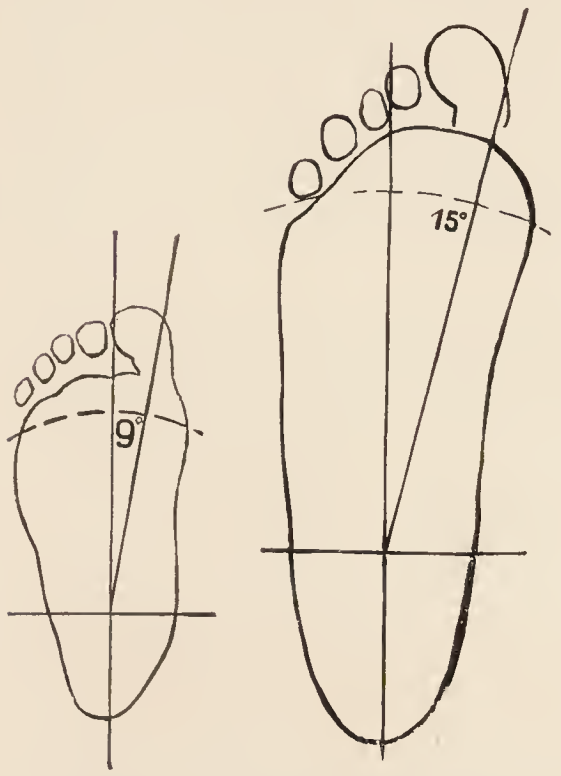


FIG. 414.—Abduction or deviation outward at medio-tarsal joint from normal angle of deflection known as valgus. (*Roberts.*)

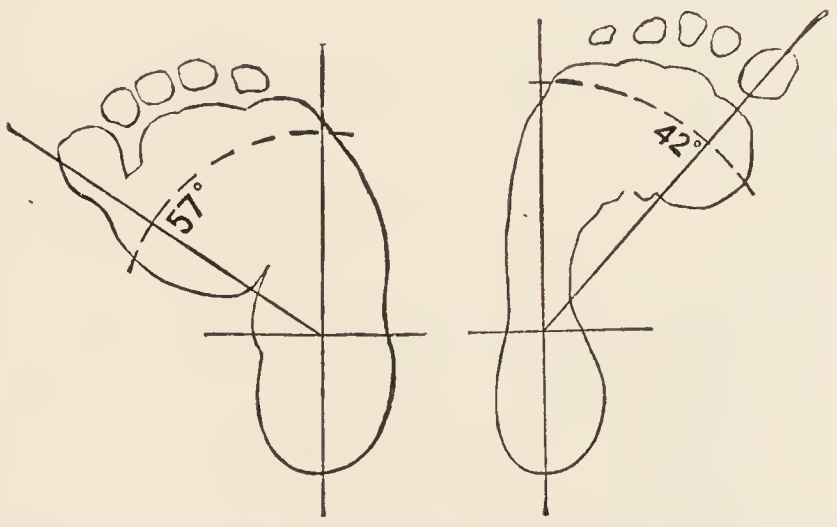


FIG. 415.—Adduction or deviation inward at medio-tarsal joint from normal angle of deflection, known as varus. (*Roberts.*)

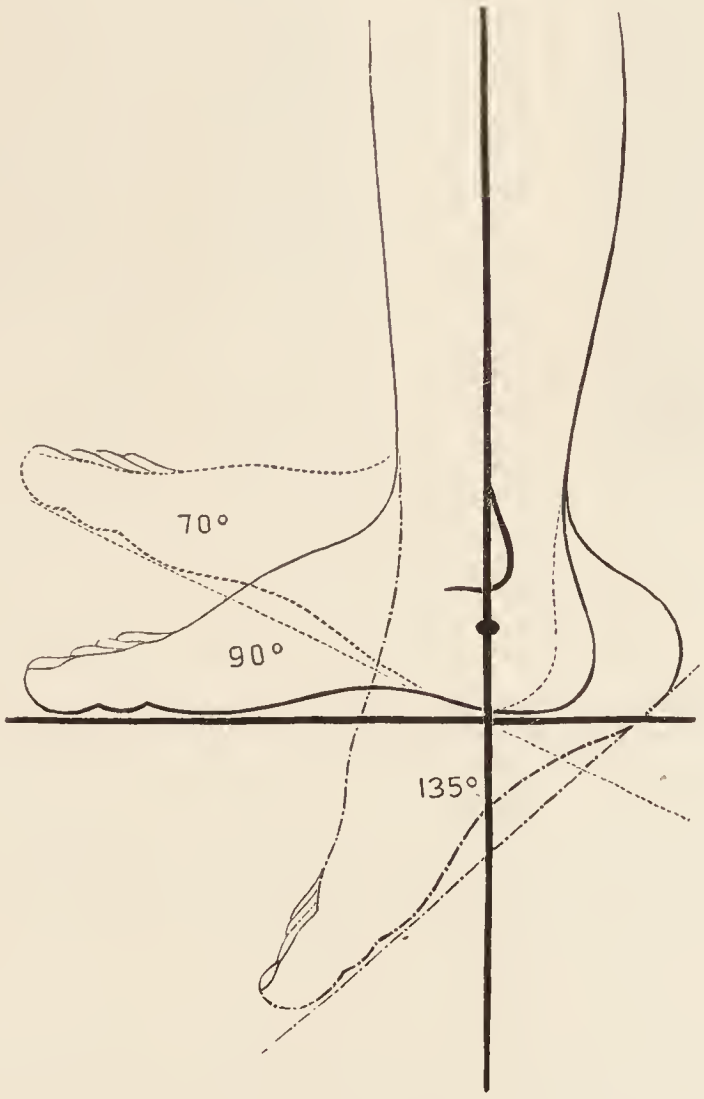


FIG. 416.—Normal position and range of motion at ankle joint. (*Young.*)

Normal Position of the Foot in Relation to the Leg.

The normal position of the foot with relation to the leg at the ankle is at an angle of 90° and extension of the foot with the leg (plantar flexion) should be

possible to 135° and flexion (dorsal flexion) to 70°. Motion less than this is pathological (Fig. 416).

Supination and Pronation.

In the normal position, the foot on its long antero-posterior axis is neither rolled downward and outward, which is known as "Supination," with the weight borne chiefly on the outer side, nor rolled downward and inward into "Pronation" with the weight largely on the inner side, but is borne equally on each of the three piers, namely the heads of the first and fifth metatarsals and the tubercles of the os calcis.

Pronation and Supination take place at the subastragaloid joint and to a certain extent at the ankle joint. These positions occur from a rotation of the foot on its long axis (Figs. 417 and 418).



FIG. 417.—Normal position and pronation shown in double photographic exposure.

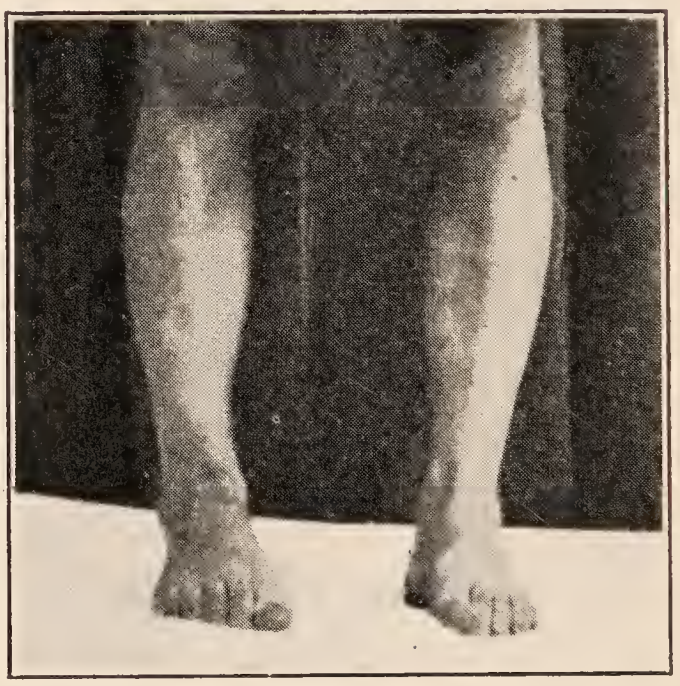


FIG. 418.—Supination.

Normal Shape of the Foot.

The normal shape of the inner border of the foot should give relatively a straight line from the heel to the inner side of the great toe from the first to the last phalanx and with the concavity of the arch well without this line and similarly the front and outer border should be slightly convex.

Meyer's Line.

Further to insure the proper angle of deflection of the fore-foot to the heel and proper alignment of the phalanges to the metatarsal of the great toe, a straight line passing from the centre of the heel through the ball of the great toe should pass through the centre of the distal end of the great toe. This is known as "Meyer's Line" (Fig. 419).

Feiss' Line.

In the normal foot, if a line is drawn from the lowest point of the internal malleolus to the tubercle of first phalanx of the great toe, on this line will be found the tubercle of the scaphoid. This is called Feiss' Line. If the arch is lowered, the tubercle of the scaphoid will be below Feiss' Line and if the arch is abnormally high, the tubercle will be above Feiss' Line (Fig. 420).

Foot Prints or Impressions.

At times it is desirable for purposes of record or diagnosis to obtain foot prints and this can be most simply done by having the patient wet the sole of the foot and step on a dry board or if the tracing is to be preserved, have the patient's foot greased with vaseline or olive oil and have him step on a piece of paper or card-board which can then be dusted lightly with plaster of paris and the excess shaken off and record dried (Fig. 421).

Or, a piece of card-board can be smoked by burning camphor and then the impression made by standing on the sooted paper. To avoid smudging,



FIG. 419.—Meyer's line.



FIG. 420.—Feiss' line.

this can then be sprayed with thin shellac varnish or shellac varnish can be "run over" it (Shellac ℥i, Alcohol f℥iv).

Another very convenient method of obtaining foot prints for case record, which shows many details of skin markings and lines, is to be obtained from painting the foot by means of a camel's hair pencil or cotton swab with Tincture of the Chloride of Iron 20, Alcohol 75, Glycerin 5, making the impression and then developing this with a weak solution of Tannic Acid, in Alcohol (0.5 per cent. or Tannic Acid griiss, Alcohol q.s., f ℥i) painted lightly over with another camel's hair brush. This gives a good black and white record and is less messy than other methods.

The value of the foot prints often enables the surgeon to determine whether the "*foot-balance*" is normal or not and to what degree there is abnormality, in a Valgus or Varus direction and even the amount of Pronation and Supination from the lowering or raising of the arches.

In the normal tracing, greatest pressure is shown under the ball of the great toe, with a clear space corresponding to the transverse arch between it and the

region showing pressure of the ball of the little toe. Then we note a fairly light shadow along the outer border of the foot from the dense shadow under the ball of the little toe to a heavy shadow at the heel. Conversely in Valgus there is a flattening of the transverse and longitudinal arches and an increased shadow in the middle regions of the foot both at the transverse and longitudinal arches, if weakness exists at both. This last described shadow has been the means of dividing Flat-foot into First, Second and Third Degree Flat-foot. Ordinarily, the shadow does not extend more than half way across the foot and if the foot print contains in addition to the impression, a pencil outline of the foot, the clear space and shadow can be divided by measure into six equal parts; so

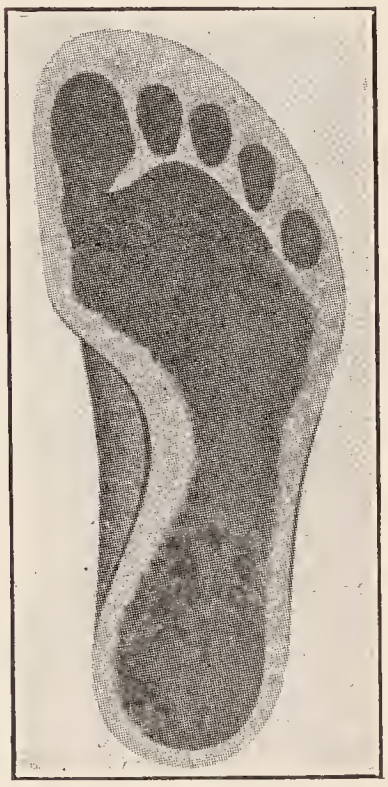


FIG. 421.—Diagrammatic representation of normal footprint, except shadow is too dense between ball of great toe and little toe as in broken down transverse arch. Shape of sole of shoe and relation of upper at shank also indicated.



FIG. 422.—"Parallel gait" in U. S. Army.

that if the shadow covers four of these we may say we have a Flat-foot of the First Degree, five parts of the Second Degree and six parts of the Third Degree.

Walking.

In walking or marching properly, as we were so insistent in the training of our army, in order to get the full potential muscular effect, the gait should be "parallel" or literally "heel and toe" and with the inner borders of the feet parallel and the feet pointed in the direction of progression as has been pointed out by Whitman and others. If the feet are everted and "toes turned out" the gait is chiefly on the heels and little or no propulsion is effected by the calf and the flexor muscles of the toes. It is the gait we associate with the flat-footed negro, German barkeeper or Jew (Figs. 422 and 423).

Similarly, we must urge the normal standing position with the inner borders of the feet parallel to secure the most stable balance with the least muscular effort and greatest muscular efficiency. We must recognize that undue strain habitually imposed on one group of muscles weakens and stretches it and relaxing at the same time the opposing muscles, causes them to shorten, undergo adaptive contraction and further stretch the overburdened group. When tired and *exhausted*, this last group will throw all the burden on unyielding ligaments, with pain, as a result, in the nerves supplying the periosteum from whence these ligaments spring (Figs. 424, 425 and 426).

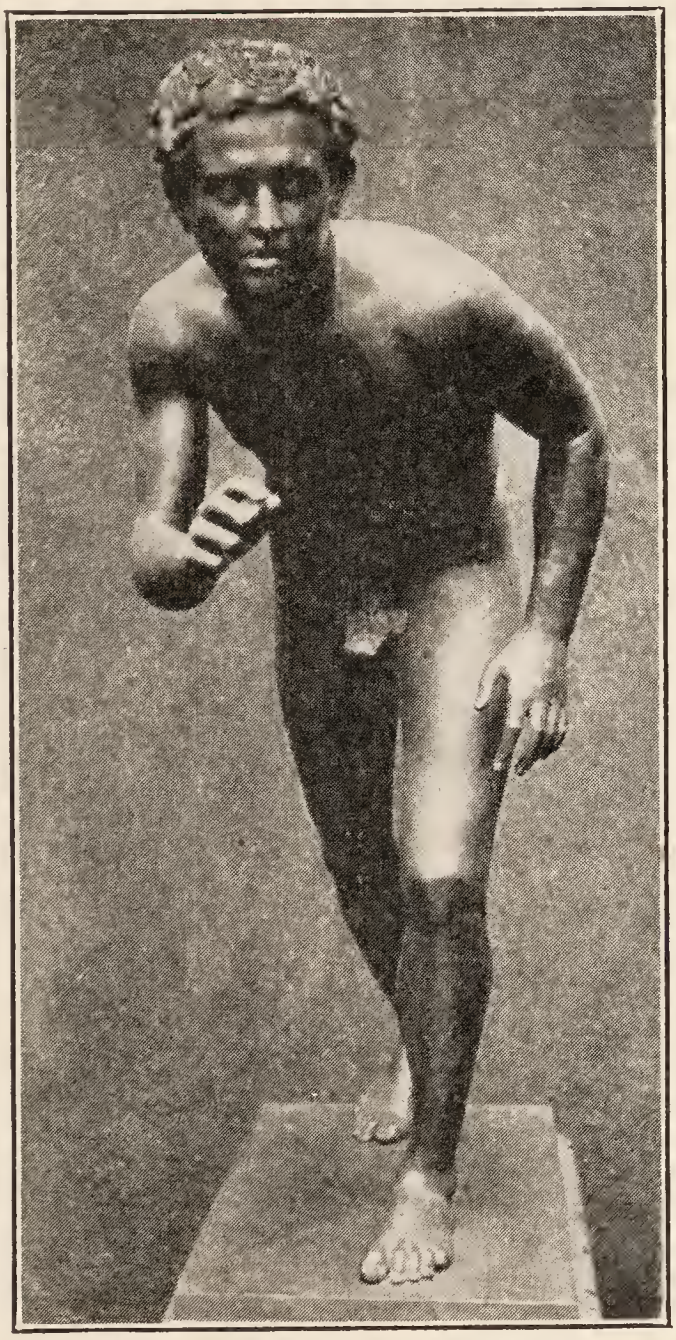


FIG. 423.—"Parallel gait" in Art; "The Runner."



FIG. 424.—"Parallel standing position" in bare-foot tribes of great endurance in use of feet and legs as shown in Philipinos. (*Hoffman.*)

Eversion and Inversion.

In conclusion, it should be understood and appreciated that turning the toes out, "slew-footed" or "fly-footed" is "Eversion" and "pigeon-toe" or "parrot-toe" is "Inversion" and are controlled by the overaction of the outward or inward rotators *at the hip joint*, as the case may be, and have no relation to the foot itself, except being pathological in the resulting foot function. These act as predisposing elements in the causation of certain foot deformities or disabilities (Fig. 427).

Thus eversion, abduction of the fore-foot (usually from improperly shaped shoes) and Pronation (which readily follows eversion) are potential and predisposing to Weak- or Flat-foot, whereas nearly always we find inversion, adduction and supination in Club-foot (Fig. 428).

One, however, must not lose sight of the fact that limitation of normal motion in any given direction, also constituted a disability or a variety of the loss of foot function. Even though no actual deformity occurs, such as that described by Shaffer as "Non-deforming Club-foot," in which the shape of the foot may be normal, but the tendo achillis is shortened and the foot cannot be

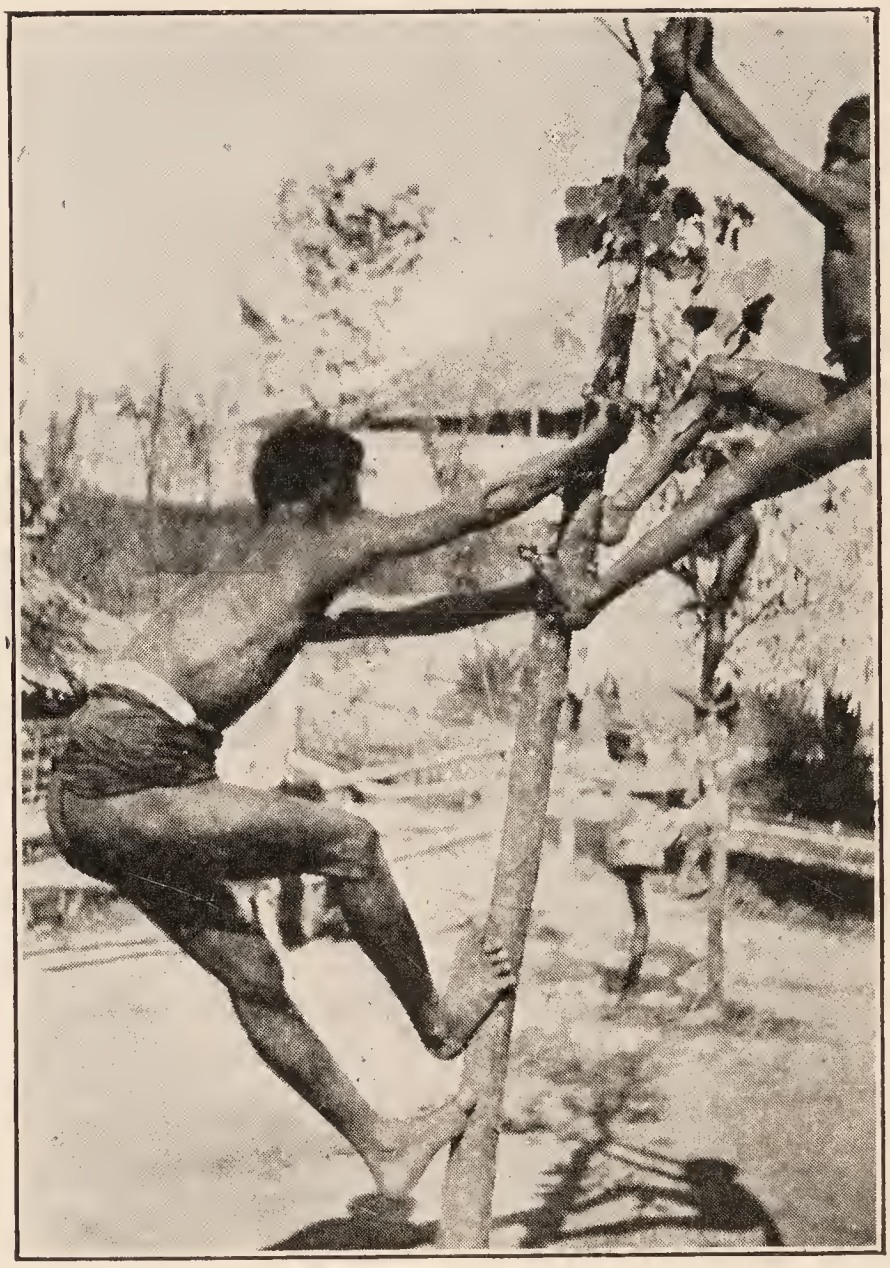


FIG. 425.—Philipino prehensile use of great toe. (*Hoffman.*)

dorsi-flexed. Vice versa with normal motion, in a "Potential flat-foot" which is one in which the fore-foot is abducted, the foot everted and pronated, although no acute symptoms appear, it is more than likely that pain, limitation of motion and disability will supervene.

Then we may have a painful condition to which the term "Weak-foot" may apply, presenting no abnormality in shape nor deformity, but owing to vicious or pernicious habits in weight-bearing, such as eversion or pronation or from wearing non-anatomical shoes, harm results producing a progressive foot strain, which will so weaken the muscles that the burden ultimately comes on overstretched ligaments and finally bone distortion ensues from pathological function. Thus the etiology of "Potential flat-foot" and "Weak-foot" are closely related.

Varieties of Foot Disability or Deformity.

Having thus discussed the mechanism of the normal foot, we are in a position to take up the varieties of foot deformity that are met with. We find they readily lend themselves to division into two groups, simple or compound, depending upon whether they are caused by or due to the action or non-action of one group of muscles or two or more groups of muscles.



FIG. 426.—Philipino prehensile use of foot and great toe. (*Hoffman.*)

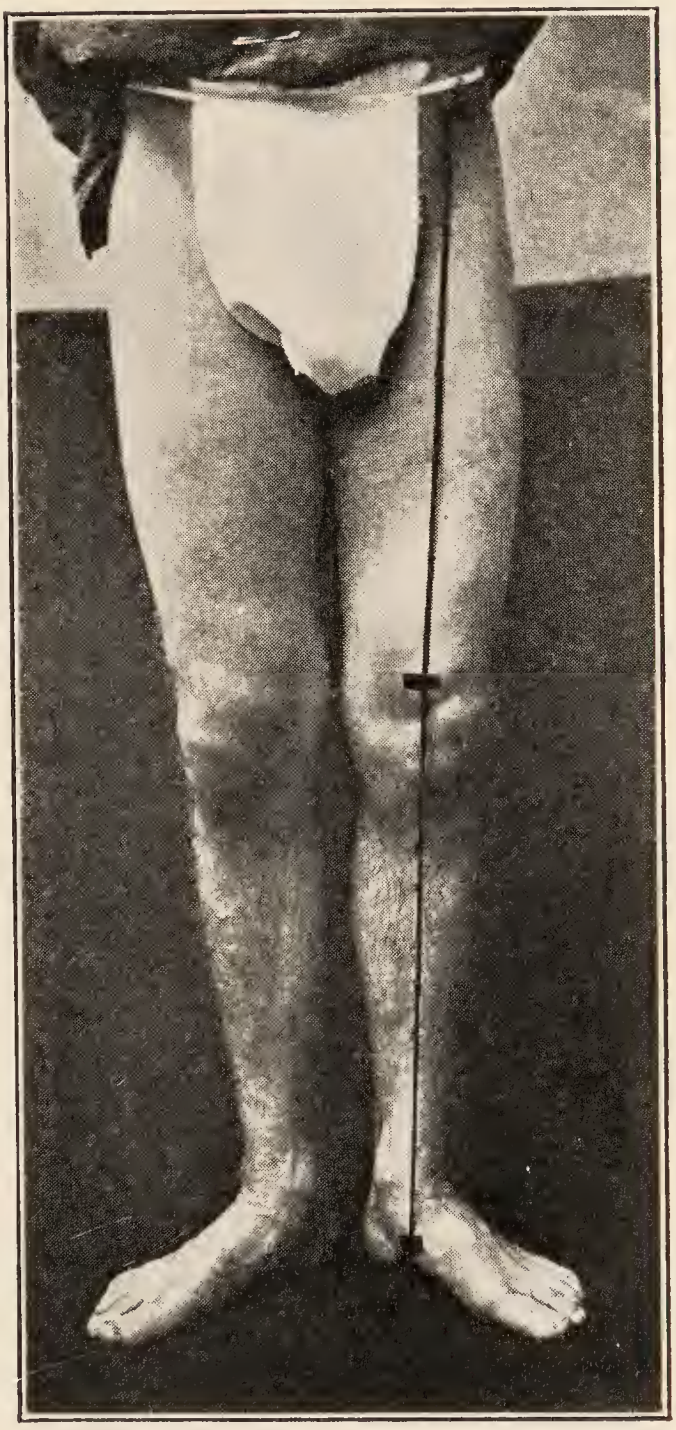


FIG. 427.—Eversion or weak standing position, weight-bearing passes through patella and arch of foot.

The term talipes is usually used as prefix to all foot deformities from the Latin words "talus = ankle and "pes" = foot.

Simple Varieties.—Simple varieties are usually seen as the result of the action of one group of muscles or the paralysis of the corresponding antagonistic group, thus we have:

1. **Talipes calcaneus,** which is a condition, where the patient walks on the os calcis due to a prolonged prenatal malposition or an attack of anterior poliomyelitis, paralyzing the calf muscles (Fig. 429).

Treatment.—The treatment of this condition depends upon whether it is congenital or paralytic in origin. If congenital, the child's foot may be soaked

in warm water, two or three times a day and the anterior groups of muscles stretched and massaged in order to get the fore-foot down and the heel up. This can have a retentive dressing applied such as a bit of surgeon's plaster

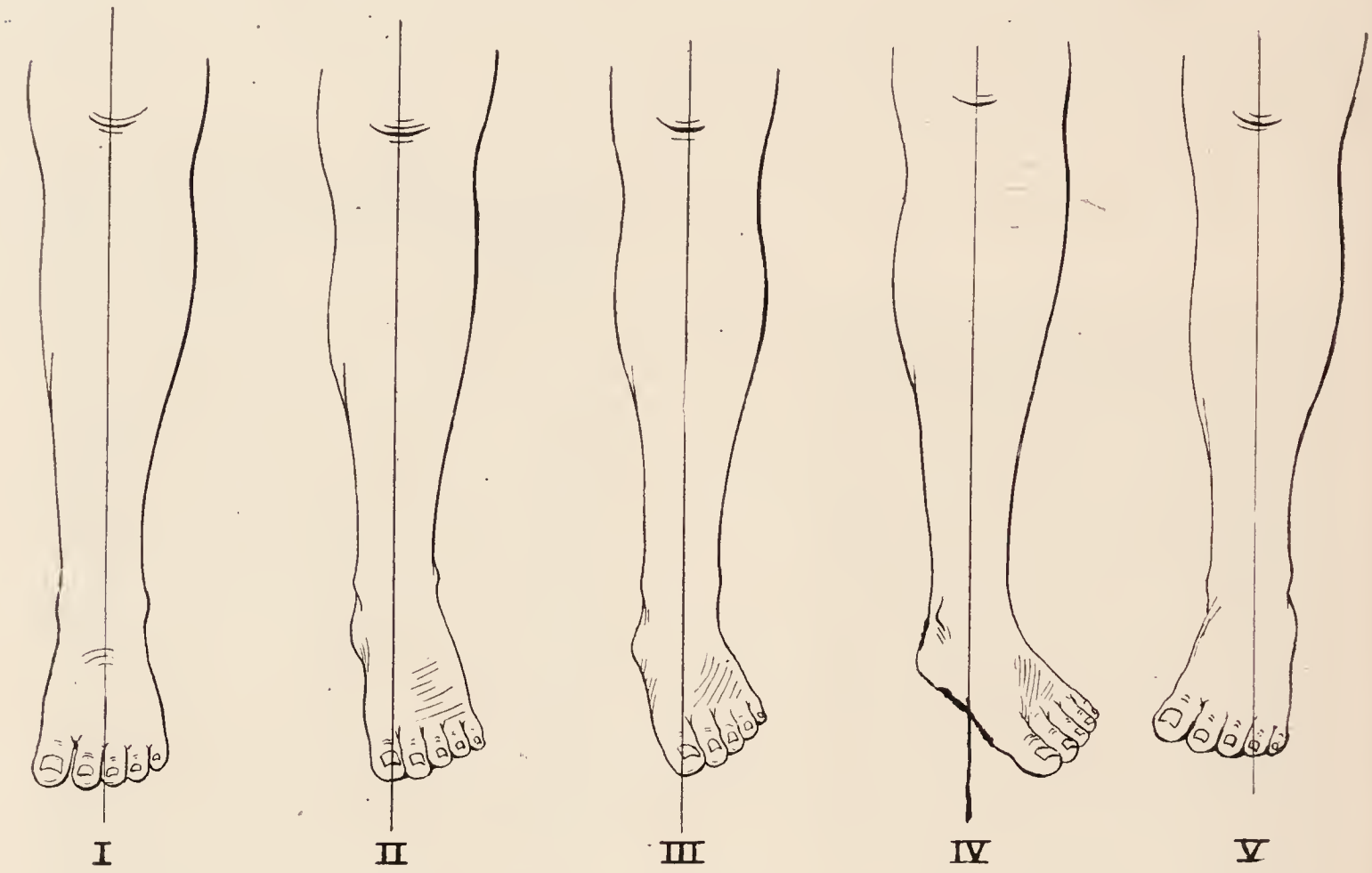


FIG. 428.—I, Normal weight bearing; II, pronation; III, eversion and pronation; IV, eversion; V, inversion and supination.

made adherent to the sole of the foot, going over the heel, strapped tightly up to the calf of the leg and held in place by a gauze bandage. Or in older babies a plaster of paris cast may be applied so that the corrected position is maintained in the intervals between the stretching and massage. In children that have been



FIG. 429.—Paralytic talipes calcaneus.

paralyzed, it is most important that deformity be not allowed to occur, so that when the clinician's findings point to paralysis of the gastrocnemius and soleus, his endeavor should be to prevent the contracture of the anterior group of

muscles by means at first of a plaster cast and later by a steel brace consisting of lateral uprights extending from the calf to the ankle joint where a "reverse stop-joint" is placed on the attachment to the stirrup that goes under the shoe. This can additionally be helped by having a cork wedge placed inside of the shoe and with its apex forward, so that the os calcis will be tilted downward and forward. Another useful aid is to have the tongue of the shoe made of sole-leather and molded to fit smoothly over the metatarsals and the front of the ankle joint. This latter device will limit or prevent dorsal flexion of the foot.

Judson's Brace.—Another brace, that will, however, not permit motion at the ankle joint, consists of an anterior padded steel band going around the front of the upper portion of the tibia and finished in the back by a leather strap. From this, two steel bands descend to the ankle and are then bent forward into an obtuse angle and join a small steel plate that goes under the ball of the foot. The brace can be worn inside of the shoe and on account of the obtuse angle holds the foot in a position of Talipes Equinus. It is supplemented by a cork wedge under the heel as previously described.

Operative Treatment.—Many cases coming to the surgeon, however, have not had preventive measures taken to avoid serious deformity and various operative procedures have been suggested to overcome this difficulty. Among the earliest suggestions for the relief of this were operations for shortening the tendo achillis.

Willett's Operation.—Among the most frequently quoted operations for this purpose is that of Willett.[1] This consists in a Y-shaped incision about two inches in total length down on the tendon to its insertion at the tuberosity of the os calcis. The tendon is dissected from the surrounding parts and divided obliquely downward and backward. The heel is then replaced in the proper position, the flaps of the tendon over-lapped and sutured. The Y-shaped incision in the skin thus becomes a V and Willett suggests that the skin sutures also pass through the tendon to secure additional fixation. The foot is then encased in plaster of paris for four weeks, when a cork wedge is placed in the shoe. This operation is especially applicable to cases in which there is paralysis of the calf muscles only and must occasionally be supplemented by a brace in the after-treatment.

Whitman's Operation.—Royal Whitman[2] suggested the removal of the astragalus and attaching the perineal tendons to the os calcis after denuding the ankle articulation of the leg bones of cartilage and also the articular surface of the scaphoid and superior surface of the os calcis. The foot, after this is done, is forced backward, so that the weight-bearing will come on the *anterior* portion of the superior surface of the os calcis and thus render the leverage more effectual in forcing the anterior portion of the foot downward. Whitman does this operation through an external lateral incision, crescentic in shape, which passes under the external malleolus. After correction of the deformity, the foot is placed in plaster of paris and later the patient is allowed to walk aided by a wedge, or sole leather tongue, or brace, as may be indicated. Lateral

[1] St. Bartholomew's Hospital Report, 1880, vol. xvi, page 309.

[2] Amer. Jour. of Med. Sci., Nov., 1901.

mobility is lessened as a result of this operation, pronation and supination are hardly possible and as inequalities of the ground require adaptability, locomotion under such conditions is hampered. The foot is stable, but too stable (Fig. 430).

Davis' Operation.—Davis[1] suggested that through an external incision good functional use followed what he called "transverse horizontal section" of the sub-astragaloid region through the os calcis, cuboid, neck of the astragalus and scaphoid to the cuneiform bones. Frequently a small incision is required also at times on the inner side of the foot. The peronei and posterior tibial tendon are retracted aside. The soft parts are freed from the bone and the leg



FIG. 430.—Whitman's astragalectomy. (*Young.*)

is pulled forward and the foot forced backward. At this point, if it is thought desirable, the peronei are transplanted into the posterior portion of the os calcis. Then the foot is put up in a plaster cast in the equinus position.

Frequently Talipes Calcaneus is associated with cavus deformity constituting Talipes Calcaneo-Cavus due to over-action of the anterior groups of muscles and the short flexors of the toes. In addition to the procedures already mentioned, division of the planter fascia and short flexors are required to correct this.

[1] G. G. Davis, Amer. Jour. of Ortho. Surg., 1913, vol. xi, No. 2, pages 231–242.

Sir Robert Jones' Operation.—In severe cases, the Jones, operation may be done, which consists of cuneiform osteotomies of the astragalus, os calcis and tibia.

Gill, Steindlar and other authorities have suggested the utilization of arthrodesis or bone pegging of the tarsal bones and Gallie and Hoffa suggested using paralyzed tendons sutured in open grooves on either side of a joint for purposes of stabilizing the joint (Tenodesis).

The Author's Operation.—The author has found in small children that tendon transplantation of the peroneus brevis passed under the tendo achillis and sutured to a groove made in the *medial* side of the os calcis, together with transplantation of the peroneus longus to the insertion of the tibialis anticus is indicated to overcome the pronation and Valgus which are nearly always asso-

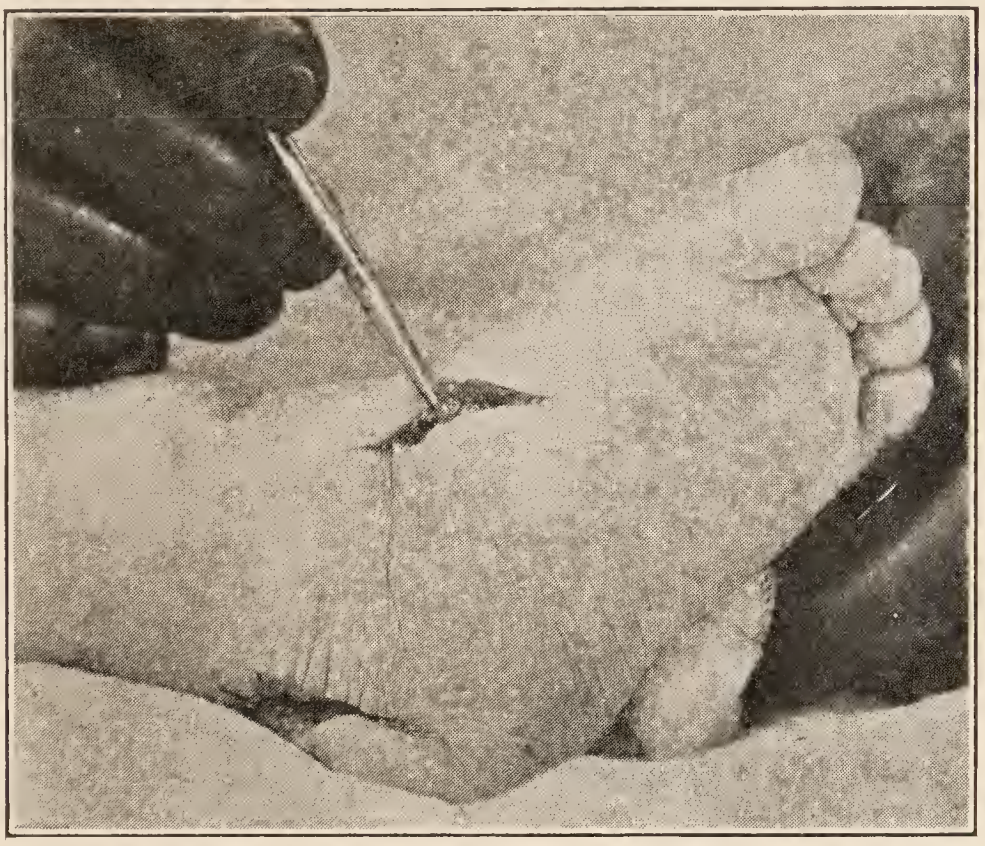


FIG. 431.—Author's operation. Incisions for transplantation of peroneus longus and peroneus brevis in talipes calcaneo-valgus. Patient shown in Fig. 429.

ciated with the Calcaneus. If the Valgus element is present, this most efficient and satisfactory operative procedure supplements the wedge inside the shoe, a wedge in the inner side of the heel of the shoe and the stiff tongue (Fig. 431).

2. **Talipes Equinus,** which causes walking on the tip toe (like a horse) is due to Infantile or Cerebral Paralysis, Tuberculosis of the ankle joint, gravity or the weight of bed-clothes following a prolonged illness. When due to Paralysis it is also known as "Foot-drop." It may be congenital from malposition in utero (Fig. 432).

Treatment.—This condition, when not due to Tuberculosis of the tarsus or ankle joint is, as a rule, readily corrected. In the new born, congenital variety, this is done by stretching and retention in strapping by surgeon's plaster or later by a progressing series of plaster casts applied with manual correction before the plaster sets. The chief difficulty in this last mentioned method is in keeping the cast on the child, as it is readily kicked off of the small foot, which is not in proportion to the size of the large leg above and will readily slip upon the instep. This can be obviated to a certain extent by strapping the cast with adhesive

plaster extending above the knee to the thigh or by applying the cast to the thigh also as well as to the leg and foot, with the knee flexed.

Operative Treatment.—In a certain percentage of these cases, the tendo achillis is so contracted that it is necessary to divide it by Tenotomy. One of the simplest operations in Orthopaedic Surgery and one of the most frequently required is transverse Tenotomy of this tendon, which is done in the following manner: Under general anaesthesia, the child's leg is rotated outward. The left hand grasps the foot and dorsal flexion of the foot is made as far as possible to put the tendon on the stretch. The sharp tenotome is entered ½ to ¾ of an inch above the insertion of the tendon, on the anterior inner edge of the tendon with the blade flat against the anterior surface of the tendon. The tenotome is then withdrawn and the blunt tenotome entered and rotated in an arc of 90° so that the cutting edge points backward against the tendon. By a gentle sawing motion, the whole thickness of the tendon is cut *through* and the foot is dorsally flexed into slight over-correction. The wound is covered with silver foil and gauze and the foot is put up in plaster in dorsal flexion at an angle of from 70 to 80° with the leg. If the difficulty is due to extensive Infantile Paralysis, involving many muscles of the lower leg, caution should be observed not to over-correct the foot too much for fear of Talipes Calcaneus resulting. The same precaution is to be observed if the Talipes Equinus is due to Spastic Paraplegia or Birth Palsy. In cases where there is total paralysis of all the anterior muscles or in cases where the gastrocnemius is unduly strong, it is necessary to put on a brace in after-treatment to prevent the recontraction of this tendon. This brace is the simple upright to calf band and stop-joint attached to the stirrup on the shoe. This is made double- or single-upright (Bilateral or unilateral) depending upon the nature of the case. In some instances with a marked tendency to recurrence, the heel on the shoe of the affected foot should be lower than that on the sound foot. In rare instances in older patients where Talipes Equinus has been in existence for a long time, "physiological transformation" has occurred in the astragalus, which will offer a bone "chock" and prevent, even after tenotomy, the bringing of the foot to a right angle or less with the leg and it is then necessary to do an Osteotomy in the neck of the astragalus and cases have been reported where an Osteotomy has been necessary in the tibia and fibula above the ankle joint, to restore the foot to its normal relationship with the leg. This last operation is, however, rarely necessary. In the after-treatment of paralytic foot-drop, the Equinus may be aided by having half-inch clock-spring steel incorporated from the ball of the shoe between the layers in the shank and heel and in a casing up the back of the shoe bent at an acute angle at the point of the heel. This will assist the weakened anterior muscles in mild cases. After the war, a spring coil of wire was used on each side of the shoe and fastened to the top of the sole and side of upper in mild cases of "Foot Drop."

3. **Talipes varus,** is the condition in which the fore-foot is adducted with relation to the heel from over-action of the abductor pollicis, tibialis anticus and associated muscles increasing the normal angle of deflection to more than 35°. This is more commonly a congenital deformity, but may follow Infantile Paralysis (Fig. 433).

Treatment.—This condition as a simple variety is rarely present and is usually accompanied by the Equinus element and will, therefore, be discussed fully under Talipes Equino-Varus.



FIG. 432.—Talipes equinus.



FIG. 433.—Paralytic talipes varus.

4. **Talipes Valgus** or **"Flat-foot"** is the reverse condition where the fore-foot is abducted from over-action of the abductor minimi digiti and the peroneus longus and brevis and is usually associated with pronation and eversion and the angle of deflection is less than 25°. It is more often seen as an acquired flat-foot, but may be paralytic in origin from involvement of the tibialis anticus and posticus and is more rarely congenital, but may be racial (Fig. 434).



FIG. 434.—Racial talipes valgus in negro showing abduction and pronation. No symptoms nor loss of function.

Treatment.—In adults or adolescents *this condition is associated with pronation and eversion.* Its treatment has perhaps received much more attention from writers than was warranted when we fully understand the under-lying

morbid anatomy of which *abduction of the fore-foot* is the chief element. In addition to the malposition just stated, we have different pathological varieties. and our treatment must be directed accordingly, depending upon the variety encountered.

These varieties are:

First, Potential Flat-foot, or, as it is often called, Weak foot, in which morphologically there is little departure from the normal contour, but this



FIG. 435.—Congenital potential flat-foot. (*Lovett.*)

departure is likely to be produced by wearing improperly shaped shoes and by habits of walking with the toes everted or "turned out," sometimes termed "fly-footed" or "splay-footed." This is commonly seen in the pictures of Charlie Chaplin, also the type of gait seen in our former German fr ends, the bar-keepers and the Militia Drum Major, who the more he turned his toes out and threw his weight back, the more he thought he was a soldier. Such habits must tend to weaken the muscles and ligaments of the arch and produce Flat-foot, as the weight-bearing comes directly down the leg to the arch and not to the elastic ball of the foot. It produces a heel gait and not heel and toe gait.

Second, we have the Flaccid Flat-foot, in which morphologically the fore-foot is abducted, the foot pronated (or not) and the arch down, but in which manually or possibly by voluntary effort on the part of the patient, the arch can



FIG. 436.—Flaccid flat-foot. (*Young.*)



FIG. 437.—Spastic flat-foot. (*Lovett.*)

be pulled up and the normal relation of the fore-foot to the heel restored or what we have spoken of as the "normal angle of deflection" can be re-established. Under this heading will fall some cases due to Infantile Paralysis or general muscular atony (Fig. 436).



FIG. 438.—Left spastic flat-foot. (*Lovett.*)

Third, we have Rigid Flat-foot or, as it is sometimes called, Spastic Flat-foot where either from habit or pain or osteo-arthritis of the tarsal bones, a spasm is present in the peroneus longus and brevis and it is not possible to

restore the foot to normal by manual or voluntary effort. Under this class one sees the Flat-foot associated with Spastic Paralysis or Birth Palsy, as well as the poly-arthritides (Figs. 437, 438 and 439).



FIG. 439.—Left spastic flat-foot.

Fourth, we have the Osseous variety of Flat-foot, which may be present as the result of prolonged Spastic Flat-foot, with or without definite ankylosis, of a fibrous or osseus nature, from prolonged osteo-arthritis of the tarsus and



FIG. 440.—Osseous flat-foot.

usually associated with arthritic changes elsewhere in other joints, notably knees, hands and elbows (Fig. 440).

In little babies, one frequently sees an apparent Flat-foot when the foot is placed upon the ground, but which in reality is due to a pad of fat fitting in the

arch and is not a true Flat-foot unless the fore-foot is *abducted* with relation to the heel. If the true deformity is noticed prior to walking, much can be accomplished by stretching the outer ligaments and muscles of the foot by grasping the heel with one hand, so that the ball of the thumb presses in against the arch when the fore-foot is adducted with the other hand. Later on, it can readily be cared for by a proper shoe such as the "Pediforme" or any shoe made on anatomical lines of adduction and with a slight elevation of the heel on the inner side of say ⅛ of an inch.

As a rule, the Potential and Flaccid Flat-foot are accompanied by progressively increasing pain and disability and are seen in the acute painful stage by the surgeon chiefly in late adolescence or adult life, especially in those whose occupation requires prolonged standing or walking. Such occupations are those of bakers, barbers, motormen, conductors, doctors, nurses, policemen, shop girls and employees in many industrial plants. Some of these are debilitated by their mode of life, serious illness or a damp environment. These people have cultivated unconsciously, as a rule, the vicious habit of walking and standing with the toes turned out.

Habit in Standing and Walking.—One of the first things that they should be instructed to do is to practice and make a habit of "parallel standing" and "parallel walking" with the inner edges of the feet parallel or in severe cases even being taught to walk slightly pigeon-toed.

Contrast Baths.—Next, for the pain, nothing gives relief as much, aside from absolute rest in bed, as the "contrast bath" used twice or more frequently daily. This bath is obtained by utilizing two buckets of water, in one of which there is water at approximately 105° to 110° and in the other tap cold water or even one in which ice has been added to give a temperature of approximately 40°. The painful foot is emersed in first the hot water for a few minutes until thoroughly warm and the pain is lessened and then placed in the other for a few minutes for its tonic effect. This procedure is repeated several times at each sitting placing the foot alternately in hot and then in cold water.

Rest.—If the pain is extreme, the patient should be put to bed and the foot should even be placed in plaster of paris and the cast molded to hold the fore-foot in extreme adduction for several weeks. In Osseous Flat-foot, adhesions are to be broken up under an anaesthetic and in the spastic variety the peronei tenotomized, after both of which procedures the foot is to be placed over-corrected in extreme supination and adduction at a right angle to the leg for a number of weeks prior to after-treatment by physiotherapy and proper shoes.

Strapping.—If the case is not severe enough to justify putting to bed and yet may be classed as an Acute Foot Strain, the foot can be strapped with surgeon's plaster in the following manner as suggested by Freiberg and Sir Robert Jones in order to hold the foot in adduction, supination and at a right angle to the leg.

The patient is seated upon a table with a loop of roller bandage around the ball of the foot, the two ends of the loop being held by the patient, who has the legs crossed so that the surgeon can place the disabled foot in the desired position and the patient can keep it steady and in the desired position by means of the bandage. Six straps of adhesive one inch wide are torn off, three being 18

inches long and three 12 inches long. A piece of felt ¼ of an inch thick is cut in a crescent shape with its edges bevelled and of sufficient size to well fill in the arch of the foot and effect pressure against the scapho-astraguloid joint when applied. This pad is held in the desired place and an 18 inch strap of adhesive is attached to the outer side of the foot in the region of the base of the fifth metatarsal bone and then just under the sole of the foot over the pad and with tension up to the front of the shin and around the outer side of the calf in a spiral direction. Next a 12 inch strip is applied to the dorsum of the great toe, over the felt pad and around the heel to the outer side of the foot. When this application is made, a certain amount of tension is used to pull the foot more into adduction. The third strip is applied to overlap the first about ¼ of an inch and is carried from the sole of the foot up towards the calf of the leg. The fourth strip is applied overlapping the

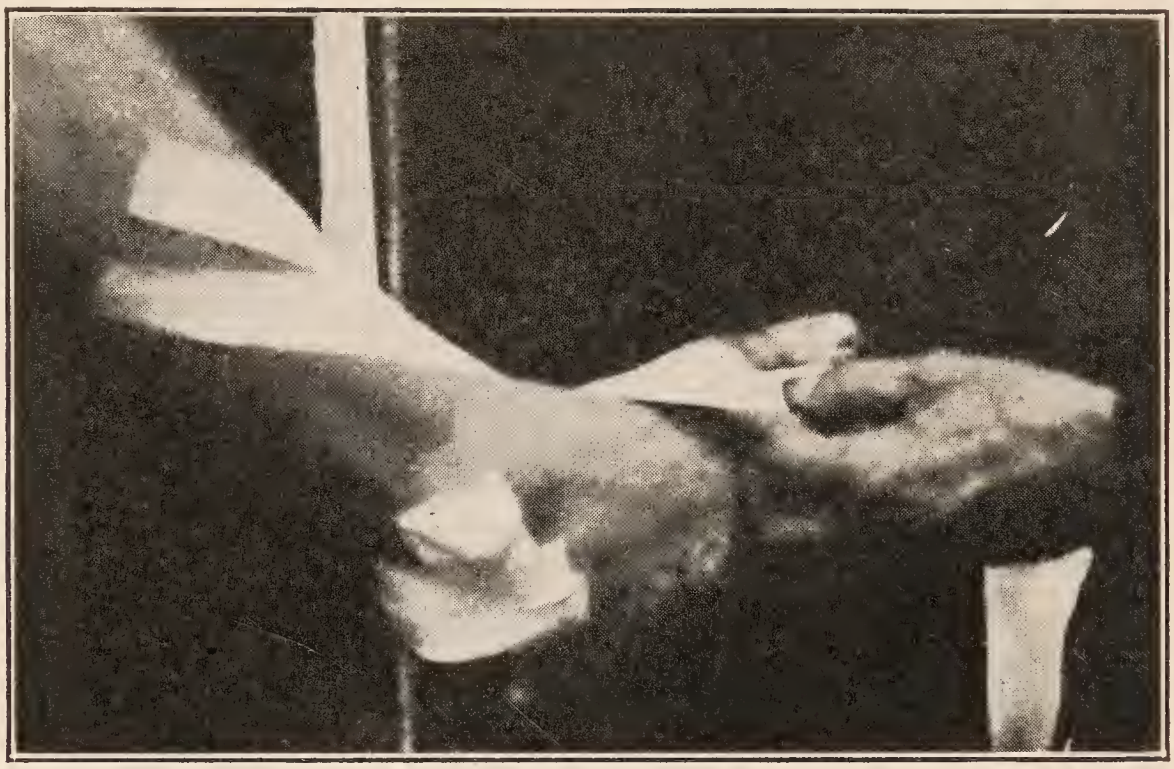


FIG. 441.—Four of the six adhesive straps have been applied for acute foot strain to overcome pronation and abduction. The fourth strap (from the heel) is seen being applied with the fore-foot well-adducted and attached on the dorsum of the 1st and 2d metatarsals.

second, the fifth overlapping the third and the sixth overlapping the fourth. A bandage worn temporarily until the adhesives stick well completes this dressing, which is often a great relief to those suffering pain of moderate severity and is to be worn until proper shoes can be obtained or with them. These shoes should have the heel of the shoe raised by a wedge ¼ of an inch on the inner side (Fig. 441).

Wedge in Heel.—This placing of the wedge of sole-leather in the heel of the shoe is best effected by removing the top layer of or the entire heel and having a wedge made ¼ of an inch or more thick, tapering down to nothing and to extend three-fourths across the heel. It is applied with the thick side inward. The original part of the heel is then nailed back into its former place. When worn this wedge tilts the os calcis and the astragalus into supination, so that this portion of the foot, where the fault lies chiefly, is relieved of undue strain. Some surgeons thicken the sole under the ball of the great toe, but this is not strictly scientific and is required only rarely. This strapping and

wedge is employed in Weakfoot or Foot Strain just as though the patient had sprained the inner ligaments.

Sprained Ankle.

In Sprained Ankle, where usually the external Lateral Ligaments of the ankle joint are torn, the strapping and felt are to be applied in the *reverse* manner to that used in weak foot and to the *outer* side of the foot with the felt over the exact point of the tear. This can readily be detected as a point of maximum tenderness. The wedge is put in the outer side of the heel to throw the foot into pronation and relieve the stress on the injured outer part (Fig. 442



FIG. 442.—All six adhesives have been applied for sprained ankle. The direction in the application of the roller bandage is shown, just the reverse of that, for foot strain.

Sole Plates for Arch Support.—If we acknowledge that Flat-foot is due to muscular weakness, usually plus faulty shoes and habits, correcting the faults, leaves us remaining the duty of strengthening the muscles at fault. If any one suggested to a man or boy that the way to strengthen the biceps muscle of the arm was by strapping a steel plate to it or having a leather pad press into it, such advice as to therapeutic measures would be called erroneous and distinctly unscientific. So it is with the foot muscles. Notwithstanding this fact, there is hardly a department store, drug store or instrument store in the land, where foot plates are not to be had and recommended as the "cure-all" for Flat-feet, when they not only must throw the foot into further *Abduction*, but *produce additional muscular weakness and atrophy* from pressure. An examination of *many of them* that can be tolerated, will show that the fore-foot is *abducted* in relation to the heel. Some surgeons have endeavored to obviate this by having a flange press against the arch and as points of counter pressure one flange against the outer side of the os calcis and one-fifth against the metatarsal, but "the remedy is more painful than the disease." Some shoes have steel in the

shanks, which are only justified in very heavy patients, but a stiff leather counter extending from the heel to the ball of the great toe is justified in a shoe to maintain the *normal "adducted" shape of the shoe.*

In shoe stores, to the writer's positive knowledge, shoes are sold purposely too large around the instep, so that a sale of a sole-plate, on which there is more profit, may be added with the statement that "Your arch is breaking down" (which the sole-plate will promptly accomplish). Similarly, the making and "correcting" of a plaster cast of the foot, molding a lead model to it for a plate, having the lead model cast in bronze, German silver or aluminium is to be condemned. While lucrative in requiring numerous fittings, office visits and prolonged treatment, it is not scientific, not to use a stronger term. Plates were interdicted by the Surgeon General's Office for the use of flat-footed soldiers during the War. In this connection, it may be fairly asked how are we to treat Morton's Toe, Metatarsalgia and Painful Calluses on the ball of the foot.

Morton's Toe.—Morton's Toe and the other disabilities named are thought to be due to the breaking down of the transverse arch of the foot from muscular weakness and undue pressure, often causing painful calluses on the ball of the foot and in the case of the first two named, causing a pinch-

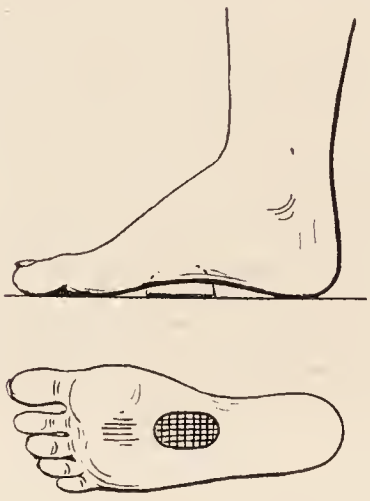


FIG. 443.—Pad fastened to shoe shank *behind* metatarsal heads for treatment of callus, Morton's toe and metatarsalgia.



FIG. 444.—Exercise standing on book with flexion and separation of toes for weak transverse arch.

ing of the nerves between metatarsal heads. A shoe, especially one with a high heel, that causes dorsi-flexion of the toes and all exercises in dorsi-flexion are naturally detrimental and further weaken the plantar and interosseous muscles, which are chiefly responsible for the maintenance of the transverse arch. Most shoes are made on rounded, *not flat nor concave lasts*, that cause the resultant shoe to be concave under the transverse arch and not convex as they should be, or at least flat, so that in an atonic foot of a debilitated person this arch cannot readily sink down. Therefore the surgeon is justified in ordering a shoe for such a patient flat on the inside in this region or even convex and furthermore in severe cases in having a bevelled pad of ¾ of an inch thick of sole-leather covered with felt, usually about 1½ by 1 inch in size, nailed to the shank on the inside of the shoe *not under the metatarsal* heads, but ½ to ¾ of an inch posterior to them to press in an upward direction on the diaphyses of these bones proximal to their heads. Such a pad under the metatarsal

heads and on the callous will, of course, increase the pain. As a temporary expedient a circular strapping around the foot at this point with a felt pad placed in the region indicated will give relief of pressure on the painful region, as a temporary expedient (Fig. 443).

These patients should stand bare-foot on a book or board twice daily and exercise the *plantar* flexors and abductors of the toes (separate the toes) fifty to one hundred times to restore muscular power and tone (Fig. 444).

Socks and Stockings.—Socks and stockings short in size and "pointed" are to be avoided as detrimental and productive of toe distortion and many foot disabilities, just as a short and "pointed" shoe does, only to a less degree.

Shoes.—The much-abused high-heel shoe is not nearly so often to blame, although they are often monstrosities anatomically and functionally ridiculous,



FIG. 445.—Anatomical shoe for men.

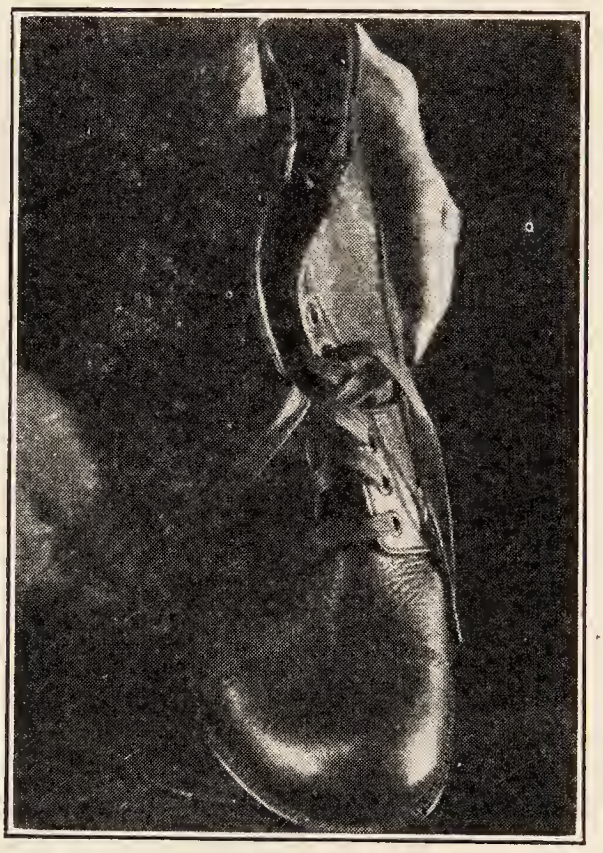


FIG. 446.—Munson last U. S. Army shoe.

as the shoe that is "pointed." It is even at times difficult to tell the right from the left under the salesmanship idea that they are "smart," "chic" and "fashionable" or perhaps, in this age of better hygiene, "in stock," when the more intelligent woman will not have such a deforming shoe "put over" on her.

Through the effort of Orthopaedic Surgeons, campaigns by the Y. W. C. A., during the War instruction in the camps and in lectures to soldiers and health lectures in the colleges, the detriment of a faulty shoe to efficient function has been stressed. The foot-sore man, woman or child cannot or is disinclined to walk or exercise. Health giving exercise promotes circulation, respiration, digestion and elimination. Without it, poor circulation, indigestion, nervous auto-intoxication, atony, flabbiness, indolence, lethargy and obesity form a train of symptoms, which the physician should do well to treat with shoes and not with pepsin nor digitalis. The publications of the Life Extension Institute have emphasized the importance of this remedial measure and it has even been suggested that legislation both national and state be enacted to make it a punishable offense for a shoe manufacturer to turn out a shoe not built on anatomical

lines and one that will be responsible for deformity or disability to the ignorant or unsuspecting purchasers (Figs. 445, 446 and 447).

The term "breaking in a shoe" is often used in connection with such a new purchase that does not fit, when pari passu surgeons recognize that "breaking in of the foot" also takes place.

Fortunately, deforming of the foot from shoes producing such conditions as Hallux Valgus, over-riding toes and Hammer Toes, if in mild degrce can be salvaged by putting on an anatomical shoe and by pads of felt, gauze or cotton between the toes under the sock and bringing them back to proper alignment. The very acute case of Flat-foot has no business wearing shoes or bearing his weight on his feet and it is far better to lay off for a week or more,



FIG. 447.—Anatomical shapes for man, woman and child.

even at the sacrifice of loss of work and pay, than to risk prolonged disability by persisting in weight-bearing. It is here that the judgment of the surgeon is called for; what cases to put to bed, what to operate, what to immobilize in over-correction, what to strap and what to permit to walk in prescribed shoes with contrast baths and exercises (Figs. 448 and 449).

Other than the Spastic and Osseous types which are readily recognized on examination, the pain and limp of the acute case is also clear from the history and clinically. They usually state that incident to their occupation or during convalescence from an acute or prolonged illness one foot began to pain in the region of the arch and on palpation a tender spot was manifest on pressure, which he will indicate is in the region of the scapho-astragaloid articulation or the sustentaculun tali. In the more severe, a general "aching" will be described and on going up-stairs there will be described a feeling that "the front of the foot would break off." Later the patient will state he had to depend on the



FIG. 448.—Army shoe inspection as to adequate length.



FIG. 449.—Army shoe inspection as to adequate width.



FIG. 450.—Well made but badly shaped shoe pointed on the inner side producing abduction.

good foot so much, that it, too, was breaking down and paining just as the first one had. Thus we have gradations from the Potential to the Acute type, which, finally, when both feet have broken down and a prolonged siege of suffering has been gone through, ligaments, muscles and bones have adapted themselves to the new order of things we reach the chronic or osseous inelastic and as a rule painless stage (Figs. 450, 451, 452 and 453).

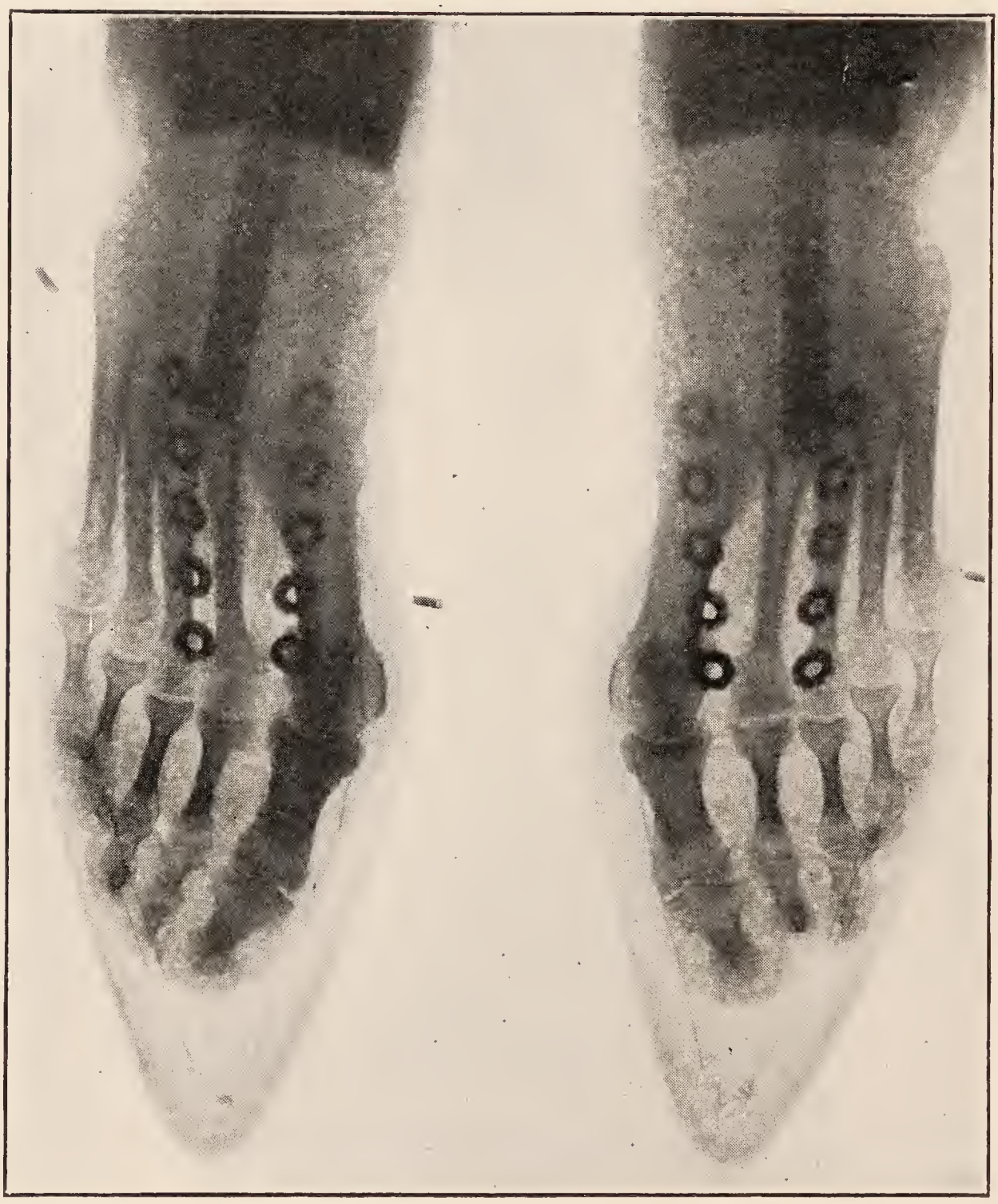


FIG. 451.—X-ray of Fig. 450 showing bone distortion.

Prescribing Shoes Made to Order.—When, therefore, the surgeon deems shoes indicated as a preventive, corrective or post-operative or therapeutic measure, the patient should be *seated* and place the foot on a sheet of paper. The surgeon, *holding the fore-foot* in as much correction, in an *adducted* direction, as he deems expedient and with a pencil held vertically, makes a tracing of the entire foot, which he sends to the shoe-maker as a guide to him in the shaping of the last. An adducted foot is, of course, shorter than an abducted one, but the shoe for an adult should be at least ½ an inch or more longer than the distance from the heel to the tip of the great toe. The shoe should be straight from the tip to the ball of the great toe and it is *most important* that the distance

from the ball of the great toe to the heel should correspond in the shoe to that in the corrected foot. The thickness of the ball of the great toe should be



FIG. 452.—Type of slipper considered fashionable (if not sensible) worn by American women shopping or perhaps mountain climbing.



FIG. 453.—X-ray of Fig. 452 showing deformity produced.

measured, as many shoes will be found of the same thickness over the ball of the great toe and little toe, which, of course, is not anatomical. The sole of the

shoe under the ball should be flat, as explained above, not concave. The shank should be narrow. A stiff counter and steel in the shank are ordered simply to maintain the shape of the shoe only if the patient is very stout. A lift in the inner side of the heel will tend to prevent pronation. A good curve around the smaller toes should be ample to prevent any pressure to cause corns, which have no reason for existence, if shoe pressure is relieved. The soles should project slightly beyond the uppers. If the basic foundation or shape is correct, it makes little difference, other than seasonal, whether a high or low shoe is ordered except that the tendons are less hampered above the ankle in a low shoe and we wish the freest play commensurate with shoe-support. An error frequently made by shoe-makers is not to have a shoe lace *together* over the instep and this *should be insisted on* as the leather *will not* stretch here and tight lacing will constrict tendons. Button shoes should not be considered, when real support is sought.

Exercise for Flat-foot.—Many exercises have been suggested for Flat-foot and other than the two suggested for correction of the flattening of the

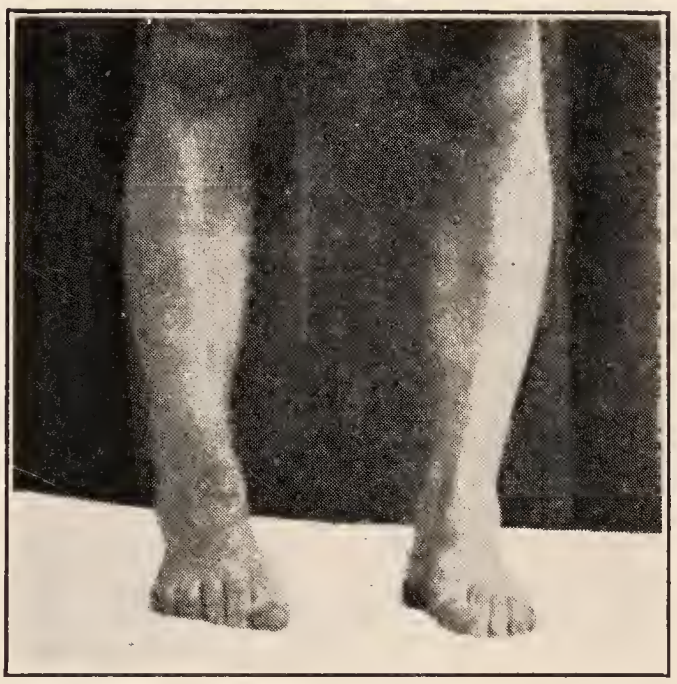


FIG. 454.—Outward rotation of thighs and legs, grasping floor with great toes and pulling up arch and overcoming pronation by action of tibialis anticus as shown by double photographic exposure. The best exercise for foot strain and flat-foot.

transverse arch, but one is really efficient for the antero-posterior arch.[1] This consists of standing with the inner borders of the feet parallel or actually pigeon-toed and bare-footed and rotating the thigh and lower leg outward at the same time grasping the floor with the great toe. A good way to teach a patient to do this is to place the finger on the tendon of the tibialis anticus just in front of the ankle and say "Pull up" or "Tighten this." As this is the muscle chiefly at fault, constant exercising of this will be most beneficial and should be done fifty to one hundred times night and morning and is but to be seen, properly done, to note the immediate correction of the deformity of Valgus and pronation and raising of the arch. As a matter of fact, when vigorously done, this exercise begins with contraction of the glutei, outward rotation of the thighs, pull on the quadriceps and tibialis anticus and posticus, so that a major portion of the muscles of the legs are exercised (Fig. 454).

[1] This exercise was first shown the Author by David Silver, whom I think credited Lowman of Los Angeles with it.

5. **Talipes Planus** is usually a congenital and racial defect among the Jews and Negroes chiefly where entire arches are lowered without any lateral deflection. They have also a lessened degree of motion in adduction and the arch



FIG. 455.—Talipes planus. (*Young.*)



FIG. 456.—Talipes cavus. (*Young.*)

may really rest upon the ground. Notwithstanding this fact, functionally, the feet are useful and painless and the term is incorrectly used, as it is in the U. S. Army nomenclature, when Talipes Valgus is meant.

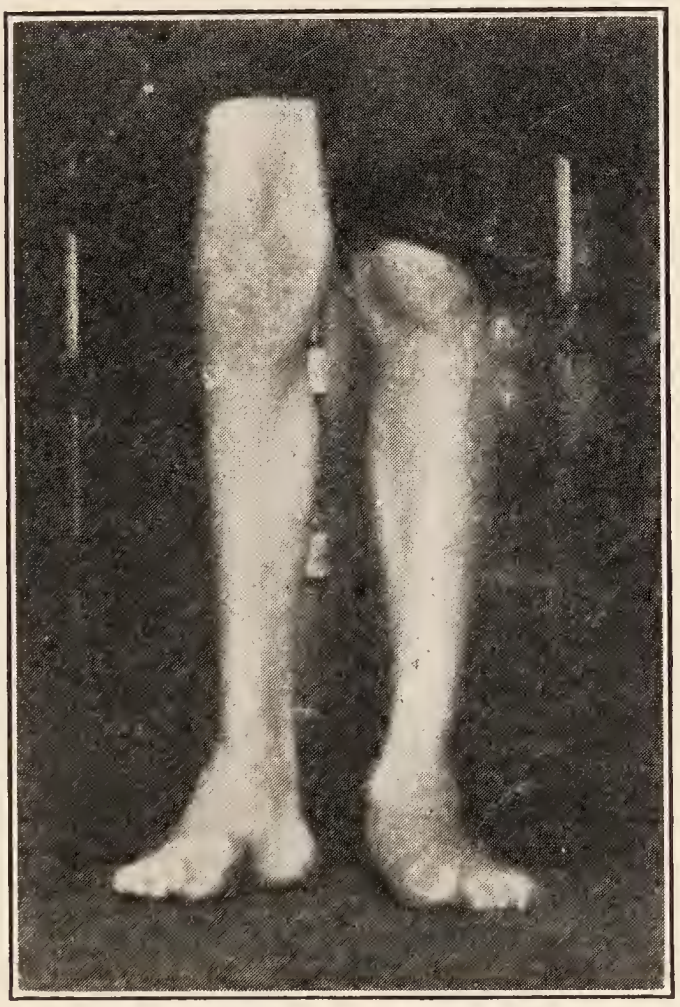


FIG. 457.—Right talipes cavus and left talipes valgus. (*Lovett.*)

Being without any symptoms and the foot having full function, as a rule, no treatment is required (Figs. 434 and 455).

6. **Talipes Cavus** is seen in cases with abnormally high arches of congenital, paralytic or racial origin chiefly among the Latin races and southern aristocratic

American women. It may follow Anterio-poliomyelitis causing paralysis of the short flexors of the toes with over-action of the tibialis anticus and peroneus tertius. It is one of the conspicuous elements in the feet of Chinese women who have been subjected in childhood to foot-binding (Figs. 456 and 457).

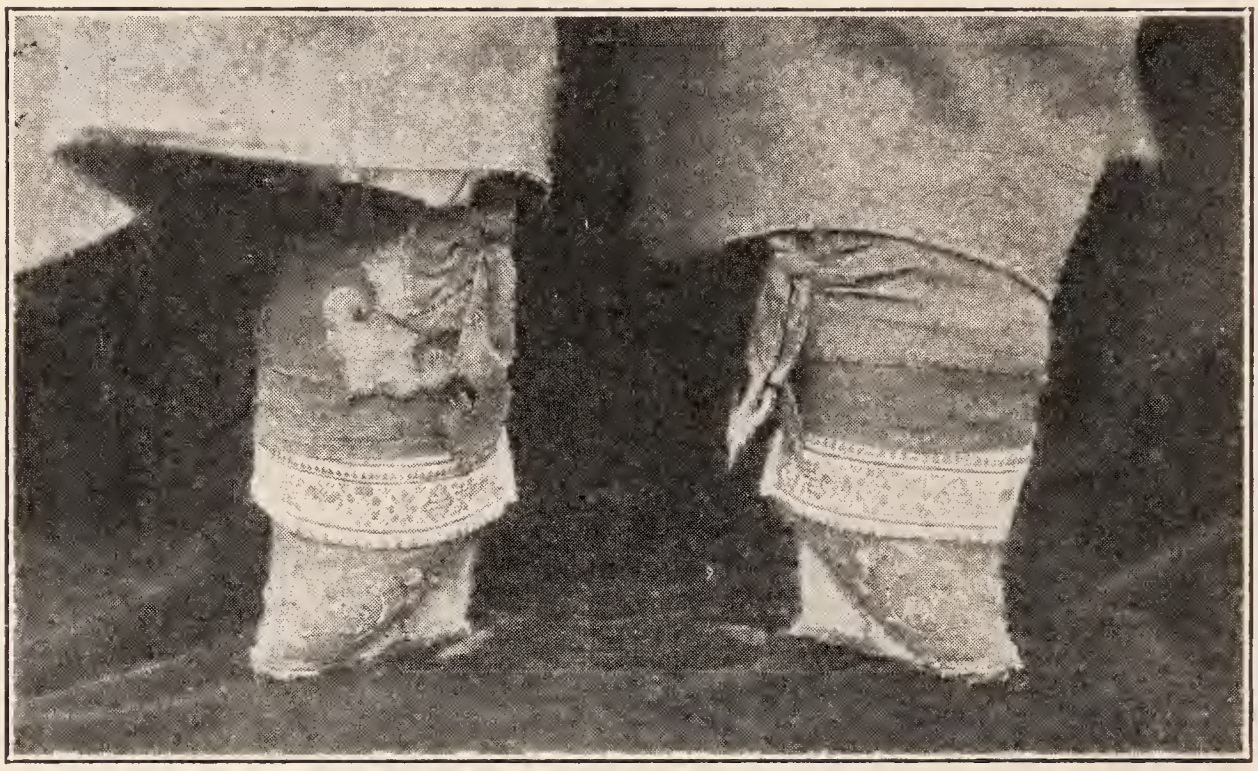


FIG. 458.—Chinese foot binding.

Treatment.—The treatment of this condition has been described under Talipes Calcaneus (Figs. 458, 459 and 460).

7. **Neuromimetic Deformity of the Foot** is seen in hysterical and neurotic patients, who may simulate any of the simple varieties as well as compound



FIG. 459.—Unbound Chinese foot. Showing equinus, calcaneus and cavus.

varieties of foot deformity. Many such cases were seen following neuroses or shell-shock in the World War.

Treatment.—The treatment of this condition properly belongs to the neurologist, as it may be classed with the hysterias.

Compound Varieties.—These consist of a combination of two or more of the simple varieties. The commonest are:

1. **Talipes Calcaneo-Valgus,** which is usually a post-paralytic deformity, is a condition in which the patient walks on the heel and the fore-foot is abducted, the weight being borne on the inner side and the arch is broken down more or less and the foot pronated.

Treatment.—The treatment of this variety has been covered in discussing the simple varieties.

2. **Talipes Calcaneo-Varus** is that variety where the weight is borne on the heel and the outer border of the foot, which is rotated on its longitudinal axis, dorsally flexed on the leg and the fore-foot is turned inward. The tibialis anticus and the flexors and extensors of the toes are shortened. This is more often post-paralytic, but may be congenital.

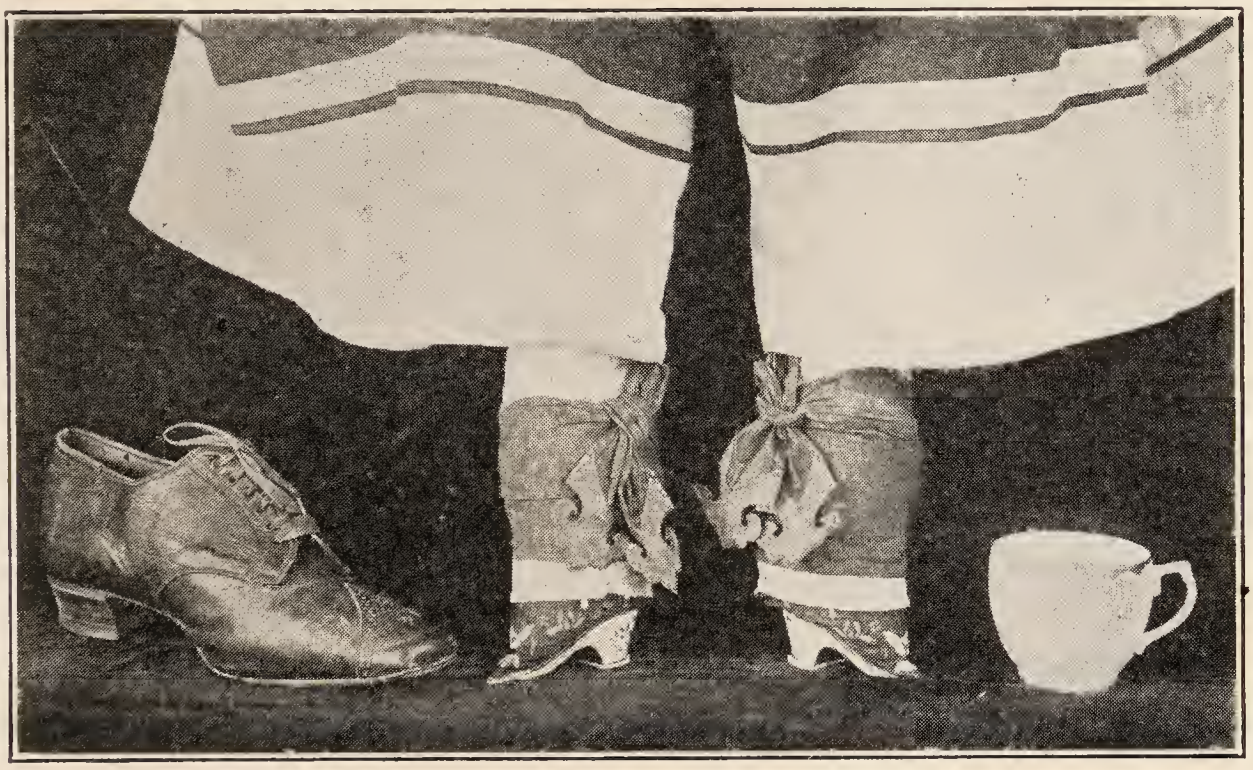


FIG. 460.—Comparison of Chinese and American woman's foot and tea-cup.

Treatment.—The treatment of this variety has been covered in discussing the simple varieties.

3. **Talipes Equino-varus** is generally spoken of as *"Club-foot"* and is perhaps the commonest variety of congenital foot deformity. It may, however, be the result of post-paralytic contracture after Infantile Palsy and by no means an unusual sequela. In this there is shortening of the abductor pollicis, tibialis anticus and posticus, flexor longus and brevis pollicis and flexors of the toes in severe cases, as well as contracture of the plantar fascia, the deltoid and long calcaneo-scaphoid ligaments. In very bad cases the scaphoid is not only sub-luxated inward, but the cuboid as well. The patient walks on the outer front border of the foot, the heel is elevated and the fore-foot is adducted and supinated.

Treatment.—Treatment of the congenital form should be begun when the child is only a day or two old and should consist in overcoming the three elements that are present; namely, the foot is in varus, it is in equinus and it is also extremely supinated. The foot is rolled on its long axis, upward and inward, so

that if the weight is borne, it rests on the outer edge of the foot or even on the superior external portion of the foot or dorsum.

It is sometimes divided into three degrees depending upon the degree of varus. The club-foot of the first degree consists of one in which the foot is adducted at an angle of 45° with the line of forward progression in walking. Club-foot in the second degree consists of one at 90° with the line of progression. One of the third degree consists of one more than 90°. In the second degree variety of double Congenital Talipes Equino-Varus the toes on the opposing feet may be pointing directly towards each other. In the most severe grade, the patient will walk on the dorsum of the foot and the fore-foot will project directly backward (Figs. 461, 462, 463 and 464).

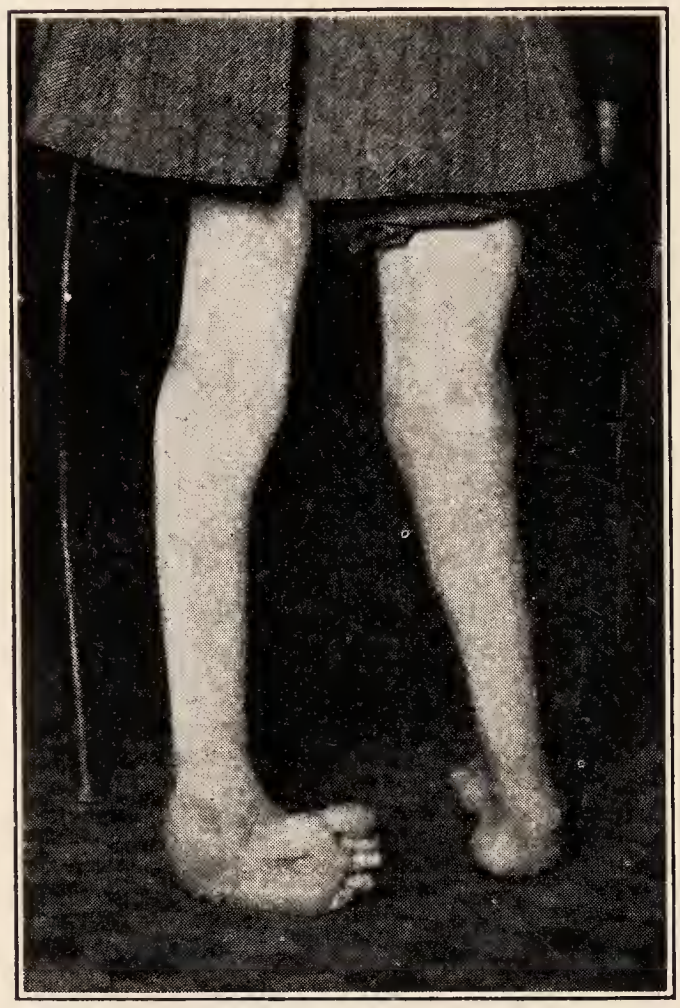


FIG. 461.—Club foot of 1st (right) and 2d (left) degree. (*Lovett.*)

This deformity, like nearly all deformities that are subjected to weight-bearing, gets progressively worse with the growth of the child and increase in weight. It is therefore, most important for the relation of the sole of the foot to the ground to be restored to normal or even in slight Valgus prior to the walking age. If this is not done, when weight is borne on the distorted foot, the bones will assume in general terms what might be called a triangular shape instead of a quadrilateral, being subjected to Wolff's Law,

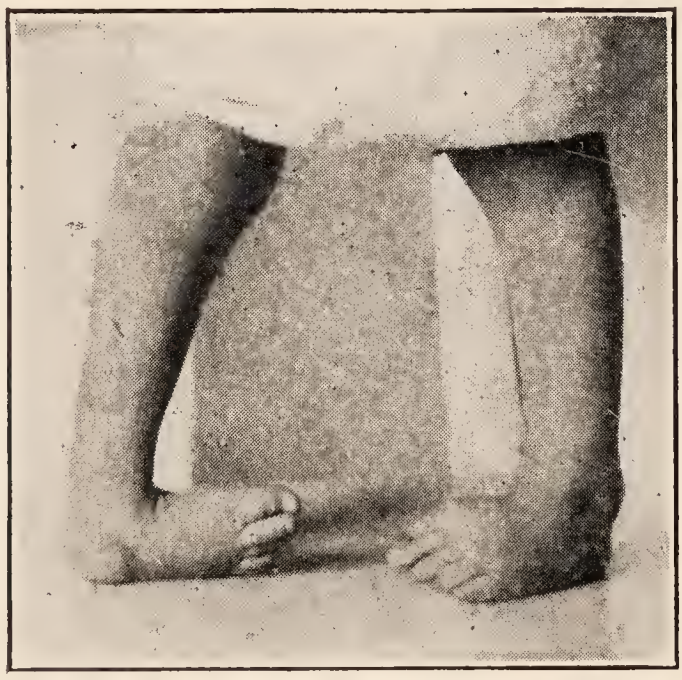


FIG. 462.—Club foot of 3d (right) and 2d (left) degree.

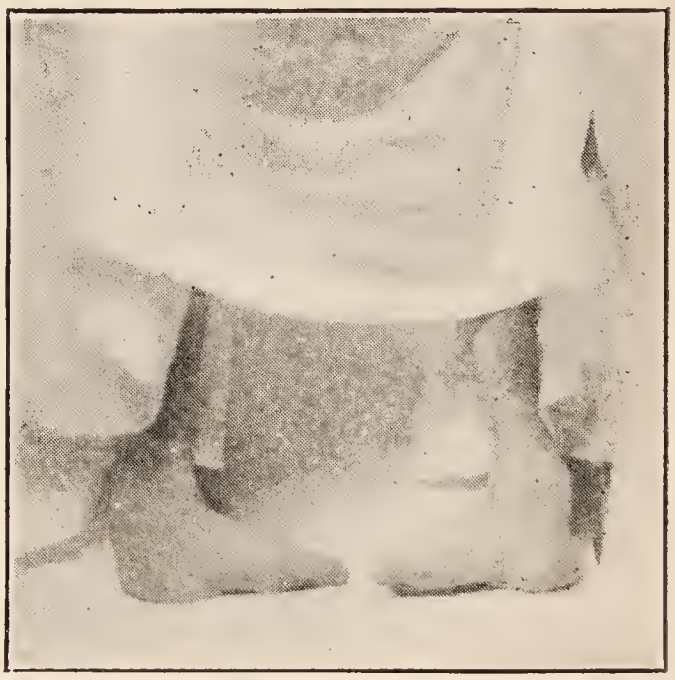


FIG. 463.—Bilateral club foot of 2d degree.

which states that pathological function produces physiological bone transformation. As the foot is unduly curved on the outer side, the bones must adapt themselves to fit in this arc.

Our first step in restoring a new born baby's foot to normal is to correct the varus and the supination elements to normal, which we can usually do at the same time. This is accomplished by daily stretching thoroughly, after immersing in warm water, in abduction and pronation. Immediately after the thorough stretching, which should consume 5 to 10 minutes, adhesive plaster should be applied on the dorsum of the great toe carried under the sole of the foot and up the leg across the shin in a spiral direction. By traction on this adhesive plaster before adhesion to the leg, much improvement can be accomplished and daily an effort should be made to further its progression. When the varus and supination elements are corrected, efforts should then be made to stretch the tendo achillis.

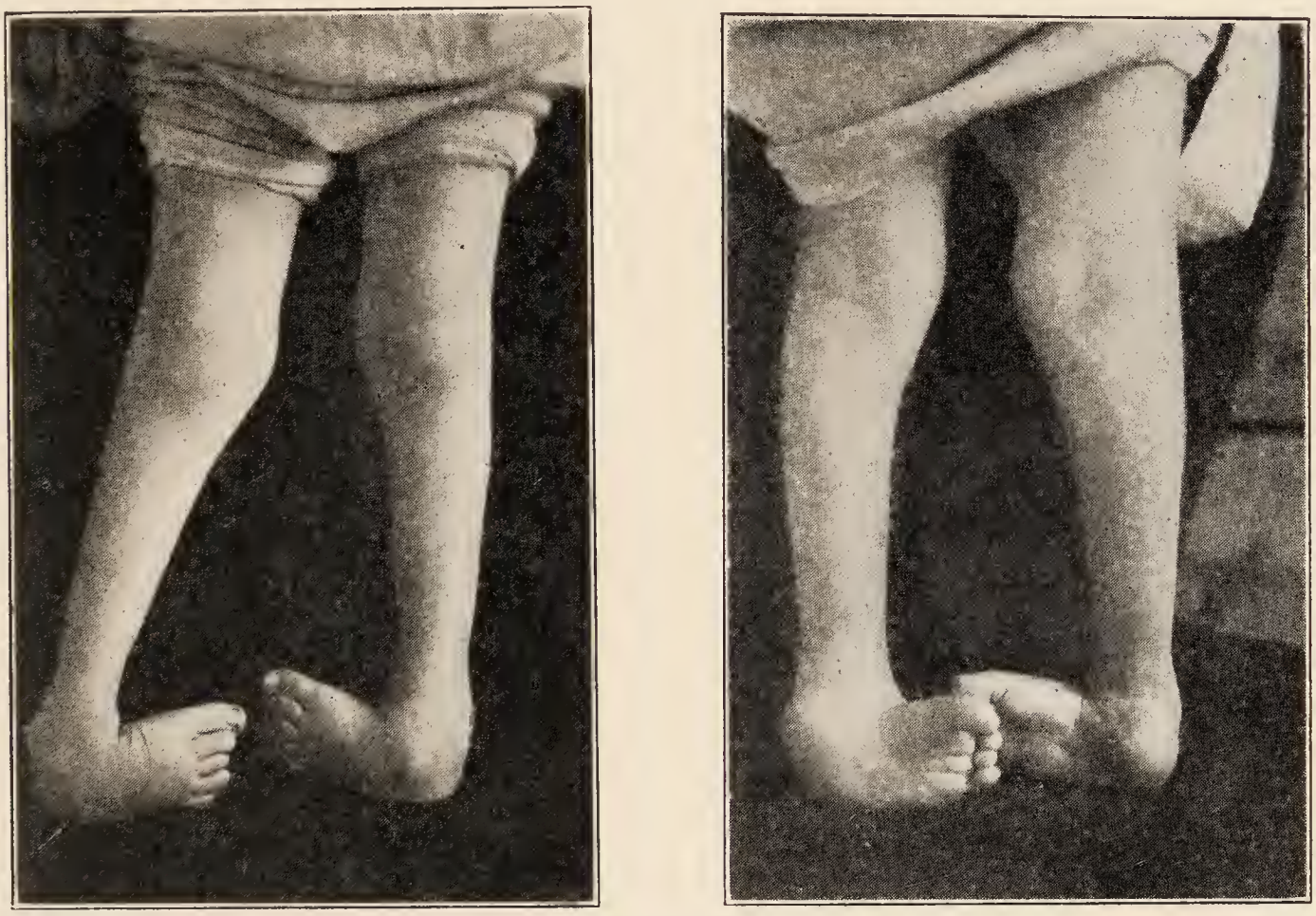


FIG. 464.—Bilateral club foot of 3d degree. (*Young.*)

Early Fixation or Brace Treatment.

After the first month or two, this is found not to be, as a rule, adequate and resort may be had to a light plaster of paris cast put on over a thin layer of glazed cotton. Care must be used, of course, not to produce pressure sloughs. At the same time, if too much cotton is used, the baby will kick the cast off. The use of casts should be persisted in until the child walks or a light steel sole-plate with a flange to prevent adduction of the fore-foot to press on the inner side of the great toe and an inner upright in the region of the malleolus to extend to a calf-band should be bent at an acute angle with the sole-plate (Fig. 469). When the foot is strapped to the sole-plate by adhesive or bandage with a gauze bandage and painted with water glass, the foot will be held in a corrected or over-corrected position in relation to the leg. In this contrivance there are two points of counter pressure; namely, the flange at the great toe and the upright at the heel and the point of pressure at the base of the fifth metatarsal.

Operative Treatment.—Unfortunately, treatment of these cases is often delayed and many children and adults seek advice and correction after the deformity has reached the second or third degree. In these, of course, each of the three elements is much more severe than in the first. Nothing short of an operative procedure will correct. The surgeon is to approach the case in a radical manner and cut all structures that offer resistance to over-correction in order to re-establish a physiological function (Phelps' Operation, Fig. 465). In the milder forms, division of the plantar fascia subcutaneously by entering a sharp and then a blunt tenotome under its inner margin and upper surface at



FIG. 465.—Position of foot after Phelp's operation. Showing large bursa on outer side. (*McKenzie.*)

the crease made between the front and the back part of the foot and dividing this fascia in a downward direction or an incision may be made down to the tubercles of the os calcis, and the plantar fascia and flexor muscles freed from it by a periosteal elevator and then stretching. After extreme stretching, the tendo achillis is divided subcutaneously by tenotomes and the foot put up in an over-corrected position. The tendo achillis, however, should never be divided until after the varus and supination elements are corrected, as one then loses all leverage in manipulation of the foot.

Next, one finds frequently cases that will not yield to the fore-going operation on the plantar fascia and must resort to division of the abductor pollicis and also the long flexors of the toes and especially the tibialis anticus. *Much resistance* is also encountered in the *intrinsic ligaments of the medio-tarsal joint*, especially those between the astragalus and the scaphoid. These can be cut

with a small sharp tenotome and much gain can often be felt after severance of these ligaments.

In the vast majority of cases, the procedures described will suffice, but cases will be encountered in which nothing short of a bone operation will produce correction. Ansel Cook, of Hartford, suggested a cuneiform osteotomy of the os calcis and possibly the astragalus just in front of the *external* malleolus, as



FIG. 466.—Left club foot of 3d degree.

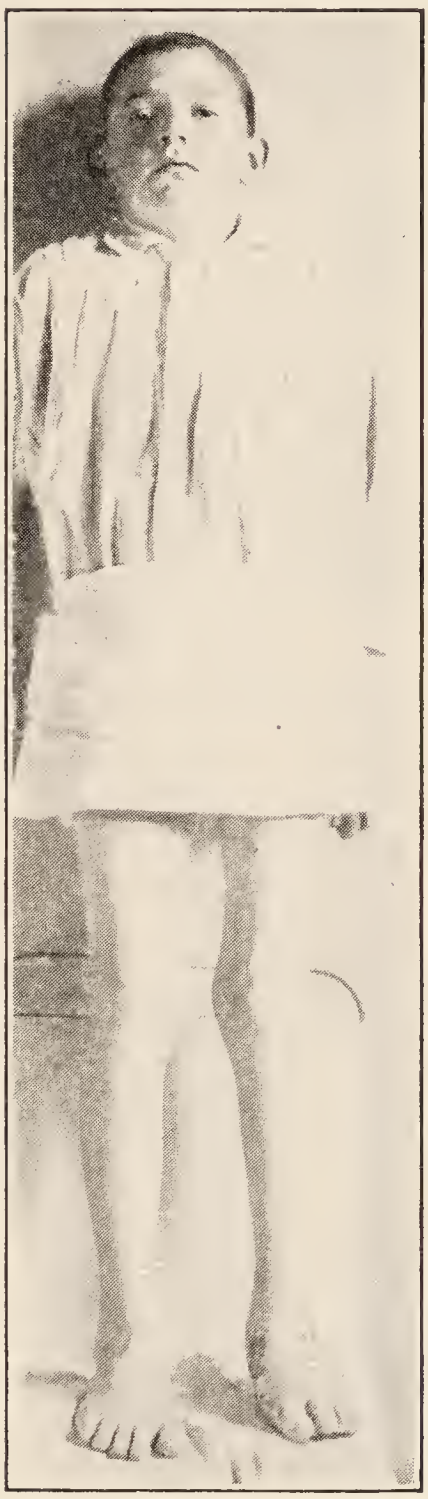
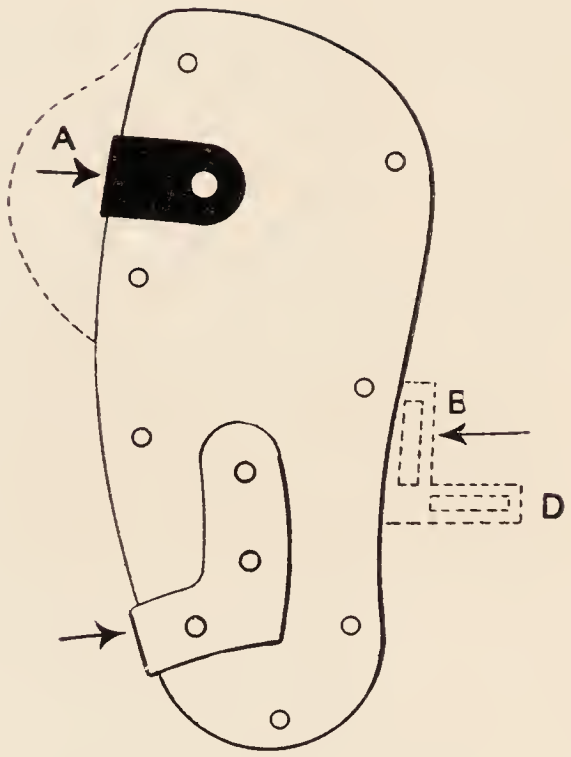


FIG. 467.—Same after Phelp's operation.

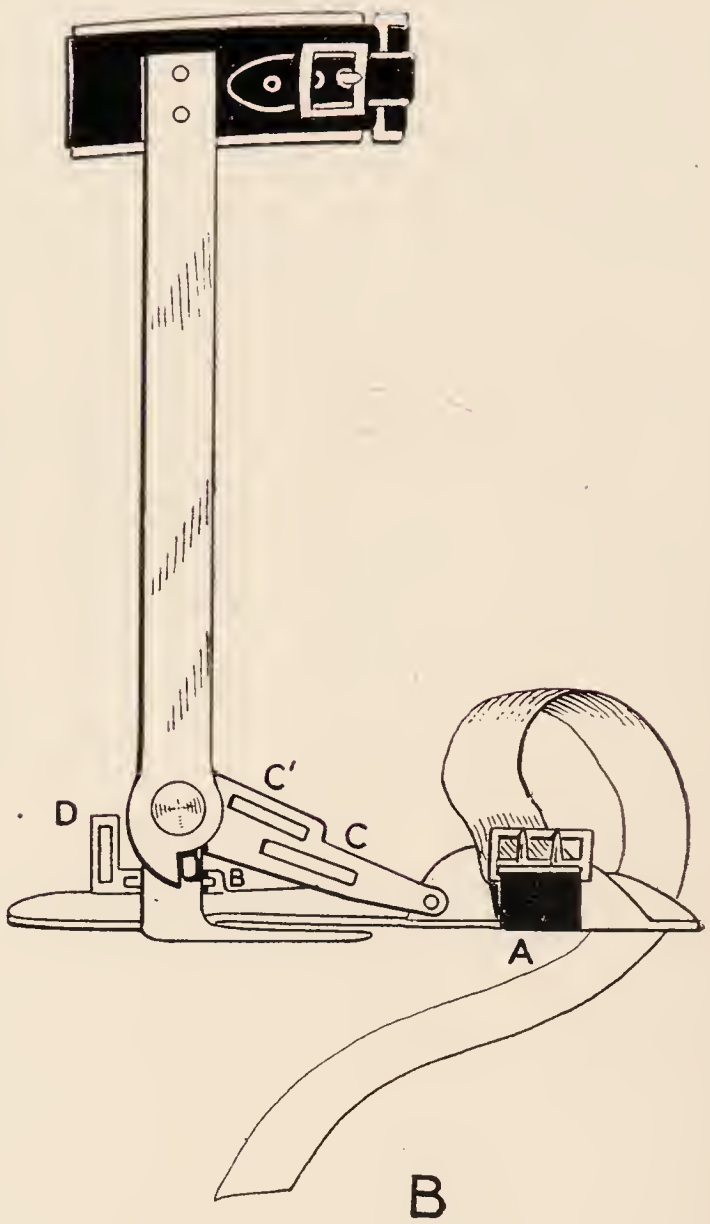


FIG. 468.—Same after wearing author's brace one year.

the best means of correction, if the soft parts were not entirely to blame and Albee has suggested removing a wedge from the outer side and placing it in the inner side of the foot as a transplant. At times it will be found necessary to do a linear osteotomy of the neck of the astragalus, especially those cases in which it is distorted by mal-use and twisted in a downward and inward direction. After all of these operative procedures, the foot must be held for a month or two in a plaster cast in over-correction and then, as the cases are quite prone to relapse, a brace of steel should be worn and over it a leather shoe, with the heel and sole under the ball of the little toe raised from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch, depend-



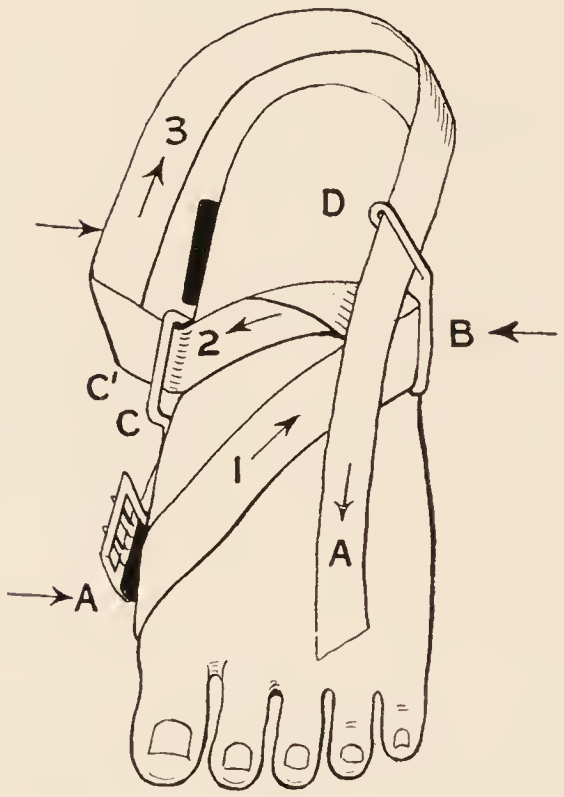
A



B



C



D

FIG. 469A.—Author's one strap brace. Sole plate. Arrows indicate points of pressure. Abducted shape. Dotted lines indicate flange A and slots for strap B and D.

FIG. 469B.—Shows medial view of brace with attachment of buckle and single webbing strap, also slots for webbing strap at CC′ and D.

FIG. 469C.—Exaggerated angle between sole plate and upright.

FIG. 469D.—Diagrammatic explanation of the direction of webbing strap from A back to A showing turn after B is passed and after C′ is passed as the strap goes around the heel (3) above the os calcis to come to slot D.

ing upon the age of the individual to throw the weight on the inner side of the foot and thus act constantly as a correcting force during locomotion.

Author's Brace.[1]—For the past 15 years, the author has used the brace presented herewith in the after-treatment or post-operative treatment fo Talipes Equino-Varus after cutting the soft parts, so often overlooked by the general surgeon and those ignorant of Wolff's Law, that "not only the external conformation, but the internal architecture of bones undergo transformation to meet new static demands," and that curved tarsal bones and badly placed articular facets, if held in an *over-corrected* position for a sufficient length of time, will become reshaped and normal. Otherwise the deformity will relapse.

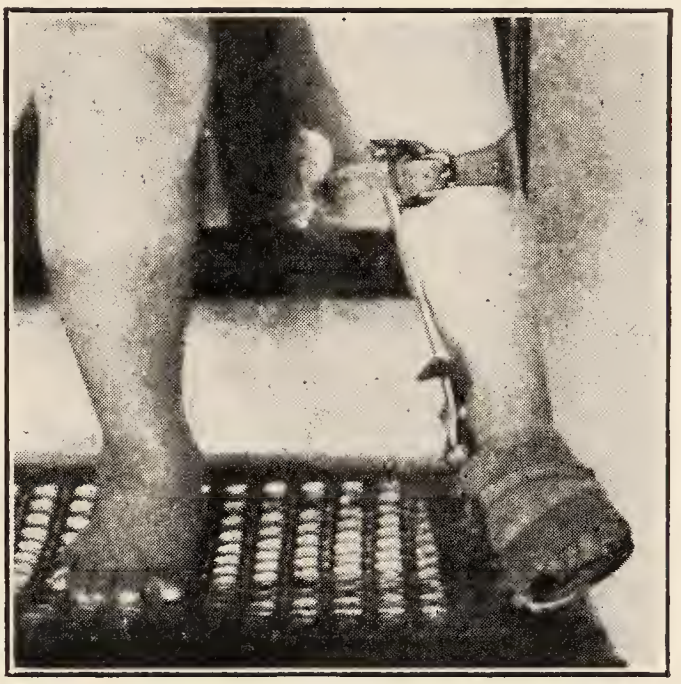


FIG. 470.—Patient wearing the author's club-foot brace without the covering shoe.

Attention is called to the abducted foot-plate, which must be narrower than the foot to grasp well the bony structure, and the single strap. The idea of the single strap was to get away from the several spikes for straps usually used and which tear the lining of the leather shoe, while it also necessitates only one buckle. The leather shoe is, of course, measured for after the brace is finished and applied to the foot.

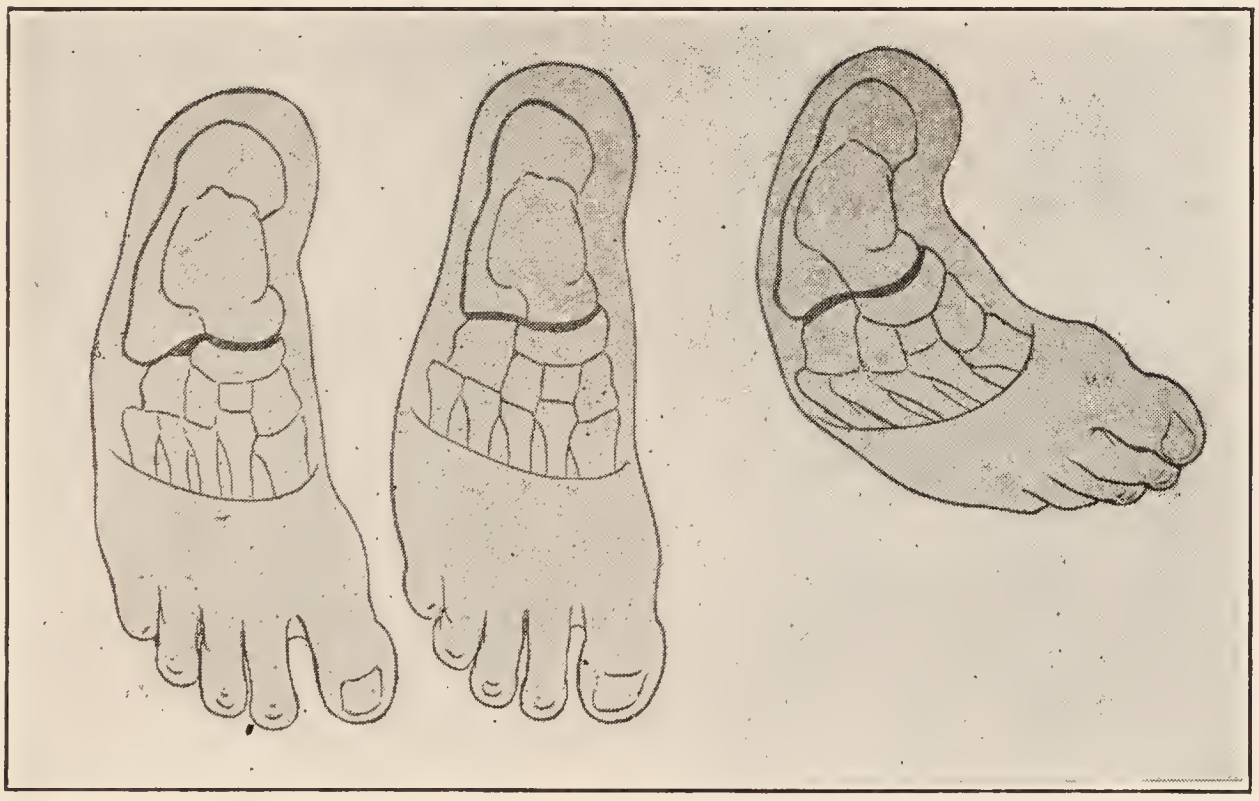


FIG. 471.—Diagram showing a partially corrected club-foot and completely corrected club-foot and a club-foot with adduction and supination. (*Bradford.*)

In these cases after correction, which show a tendency to a persistent pigeon-toe, an outside upright, with joints at the knee and hip, is attached to the steel calf-band of the club-foot brace below and a pelvic band above and by twisting this in outward rotation any degree of toeing-out desired can be obtained.

[1] Presented to the Amer. Ortho. Assoc. at Hartford, June, 1909. See the Jour. of that year.

This brace should be worn for at least a year night and day after operative correction (Figs. 466 to 471).

The reader is referred to the illustrations for a clear conception of the method of operation of this brace.

Some authorities use a wrench to aid overcorrection.

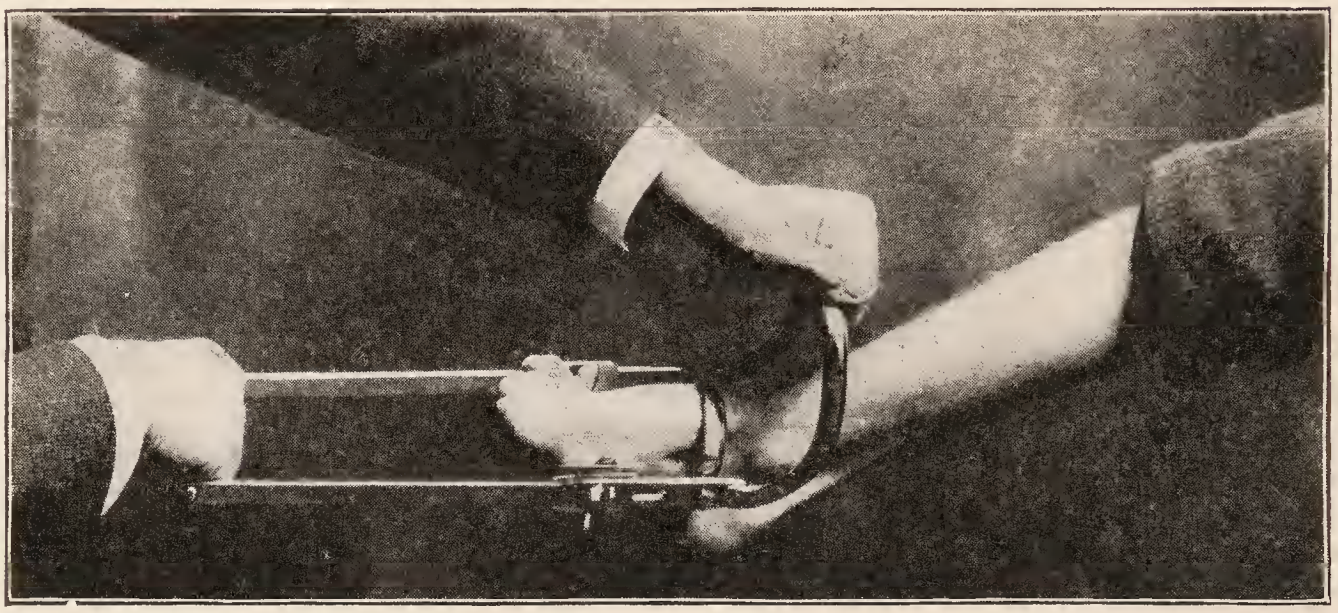


FIG. 472.—McKenzie club-foot wrench applied. (*Young.*)

4. **Talipes Equino-valgus** is comparatively an unusual deformity, but may be seen in cases of simple Talipes Valgus in which there is also adaptive shortening of the tendo achillis in both the acquired and paralytic varieties. The weight

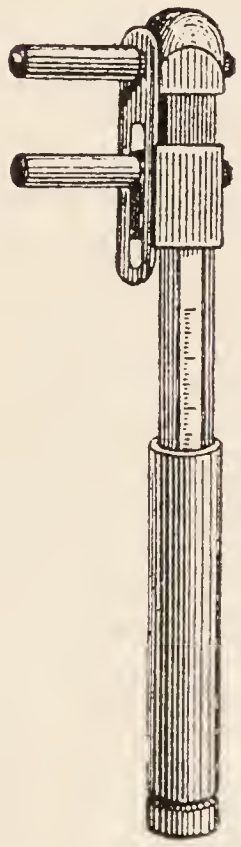


FIG. 473.—Thomas club-foot wrench. (*Young.*)

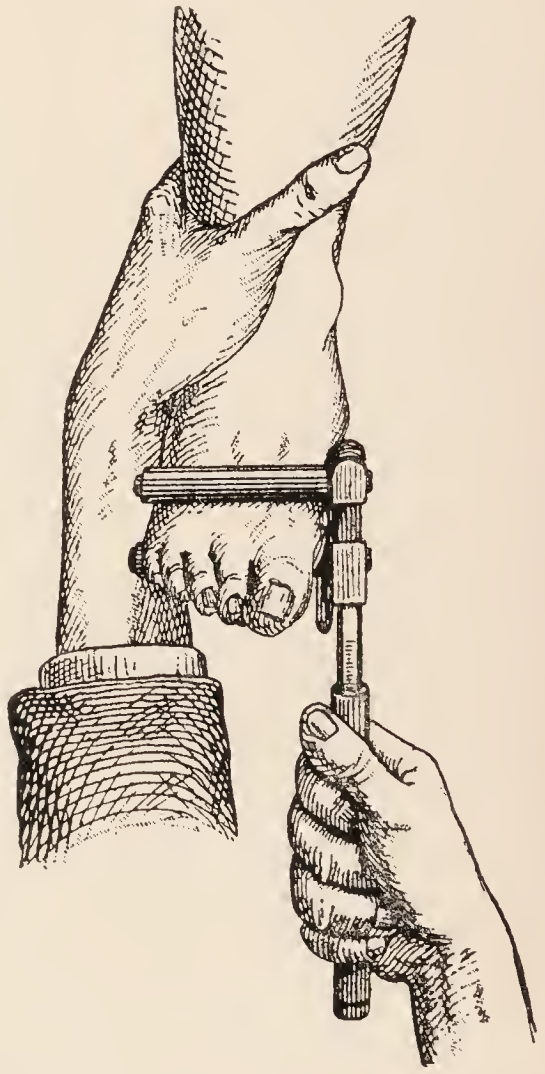


FIG. 474.—Same applied. (*Young.*)

is thrown more on the inner border of the fore-foot, which is abducted, everted and pronated and the heel is raised. It is sometimes seen in women with flat-feet whose tendo achillis has shortened from the habitual wearing of high French heels.

Treatment.—The treatment of this condition has been covered in the paragraphs under Talipes Valgus and the operative treatment of Valgus and Equinus.

Other Foot Disabilities.

1. **Pigeon-toe.**—Although surgeons interested in efficient human locomotion, regard slight pigeon-toe as a stronger method of walking and running than with



FIG. 475.—Pigeon-toes. (Inversion.)



FIG. 476.—Author's webbing and adhesive apparatus for correcting pigeon-toes.

everted feet, occasionally one will be consulted as to the best method of making a very pigeon-toed child turn its toes out and two methods are available. We must realize that this condition is largely brought about either by an increase in the angle of 12° that the neck of the femur should make with the

shaft by over-action of the inward rotators at the hip joint, so that our treatment should be directed there (Figs. 475 and 476).

Treatment.—Where it is desired to correct a pigeon-toe of slight degree, if the outer anterior corner of the heel is raised ¼ of an inch, at every step the individual makes, as soon as this projection of the heel is encountered on impact with the ground, the tendency is to throw the foot outward. Another method is to fasten adhesive plaster on the outer front of the shin, pass upward around the back of the calf to the inner condyle of the knee where a buckle is stitched. Encircling the pelvis is applied a light canvas belt and on this canvas belt are sewed buckles projecting downward and inward at a point just posterior to the anterior-superior spines and by passing webbing straps from these last described buckles to the buckles at the inner condyles of the knees, the degree



FIG. 477.—Slight hallus valgus. Flat-feet and right second hammer toe from improper shoes.

of tightness of these straps will control the degree of outward rotation of the thigh. Steel uprights from the shoes to a pelvic band with free joints at the ankle, knee and hip may be needed in severe cases. Resistive exercises to increase the power of the outward rotators of the hip should be given when the patient's legs are fully extended on a treatment table.

2. **Hallux Valgus.**—Another disability that is encountered is Hallux Valgus or a deviation of the great toe phalanges in an outward direction. This toe will not be found on Meyer's Line. This varies in degree and may constitute a painful and crippling disability (Figs. 477 and 478).

Treatment.—In its mild form, it can be corrected by discarding pointed toed shoes, which are found in a causative relation to the deformity, for one that has a straight inner edge, so that the phalanx of the great toe may be in a direct line with the corresponding metatarsal and that the great toe may be on Meyer's Line. When the normal type of shoe is worn, especially one that is thick enough from above downward to allow the great toe to come into its proper alignment, which can be accomplished by wearing pads of felt, gauze or cotton between the

great toe and the second toe under the stocking, correction will gradually occur. In the more severe cases, the bursal sac over the metatarso-phalangeal joint of the great toe may be inflamed and actually ulcerate, constituting a Bunion, requiring prolonged treatment and relief from weight-bearing, before any other measures may be taken for the correction of the deformity. If, however, the condition consists of a simple and inflamed joint from pressure and deviated toe, one of the following operative procedures is indicated.

First, a crescentic incision is made on the dorsum of the joint with its convexity outward exposing the extensor tendon of the great toe. Turning back the flap, the bursal sac is readily detached from the bone. On the medial



FIG. 478.—X-ray of moderate hallux valgus.

side of the head of the metatarsal bone is usually found a tubercle, which may be readily cut off with an osteotome and the phalanx can then often be brought into alignment.

Second, if the above procedure is not adequate to produce correction, one-third of the medial portion of the articular surface of the head of the metatarsal may be cut off and the toe restored to normal.

Third, a cuneiform osteotomy may be done in the diaphysis of the metatarsal immediately posterior to the head and by fracture alignment restored or a simple cuneiform osteotomy done in the adjacent phalanx and the deformity corrected. Under no circumstances should operations be done which *remove the head* of the first metatarsal, for thereby one of the chief weight-bearing and propulsing elements in gait are removed. Some surgeons do a resection of a

portion of a joint and turn in the bursal sac, but this is not as strictly scientific as the procedures above described which do not destroy any portion of the apposing articulating surfaces. Before the skin wound is closed up by a subcutaneous stitch, if the extensor tendon is found displaced much over the outer side of the joint like the string of a bow, it should be held in place loosely by a loop of catgut or by a covering of sutured fascia freed and transplanted over the medial side of the joint to prevent a relapse of the old deformity.



FIG. 479.—Reverdin operation for hallus valgus. (*Berger and Banzet.*)
a, *b*, *c*, Cuneiform section; *d*, *e*, section of tubercle of metatarsal; *Ex*, excised portion; *M*, bursa; *Ph*, phalanx.

After all of these operative procedures, the toe should be abducted and put in proper alignment with the foot and held by a light plaster cast rather than by wood-splinting or by "Hair Pin" wire and adhesive splint in cleft and fastened to dorsum and sole of foot (Figs. 479, 480 and 481).

3. **Hammer Toe.**—Hammer Toe, which is usually seen as a deformity of the second toe, may be a congenital familial deformity, but is often due to wearing too short and pointed shoes. This may be quite a painful disability resulting in a corn on the first inter-phalangeal joint from shoe pressure and painful pressure on the nail and tip from contact with the ground, which is brought about by pressure from undue contraction of the extensor and flexor tendons.

Treatment.—It is best not to amputate this toe, as the foot is weakened thereby and changes in the direction of the adjacent toes ensue. Resection

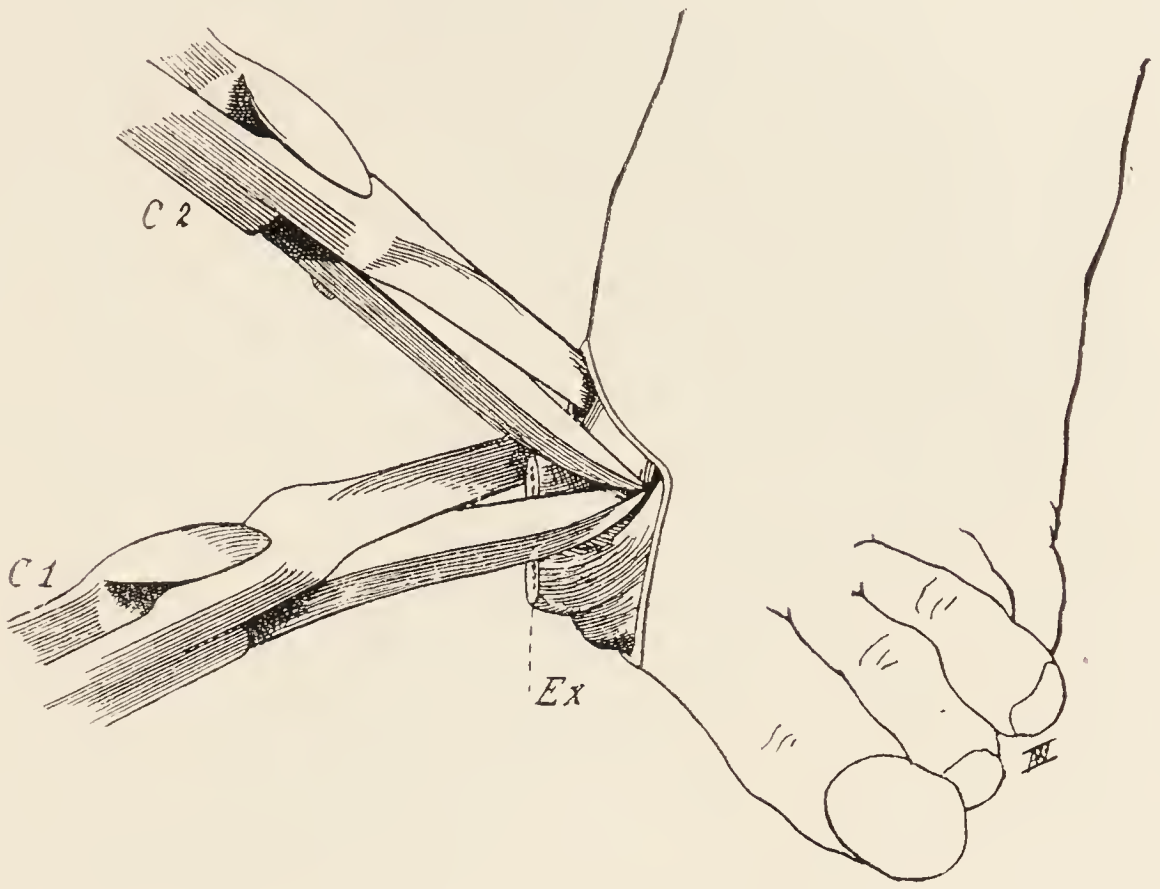


FIG. 480.—Same showing technique in removal of wedge by cutting forceps. (*Berger and Banzet.*)

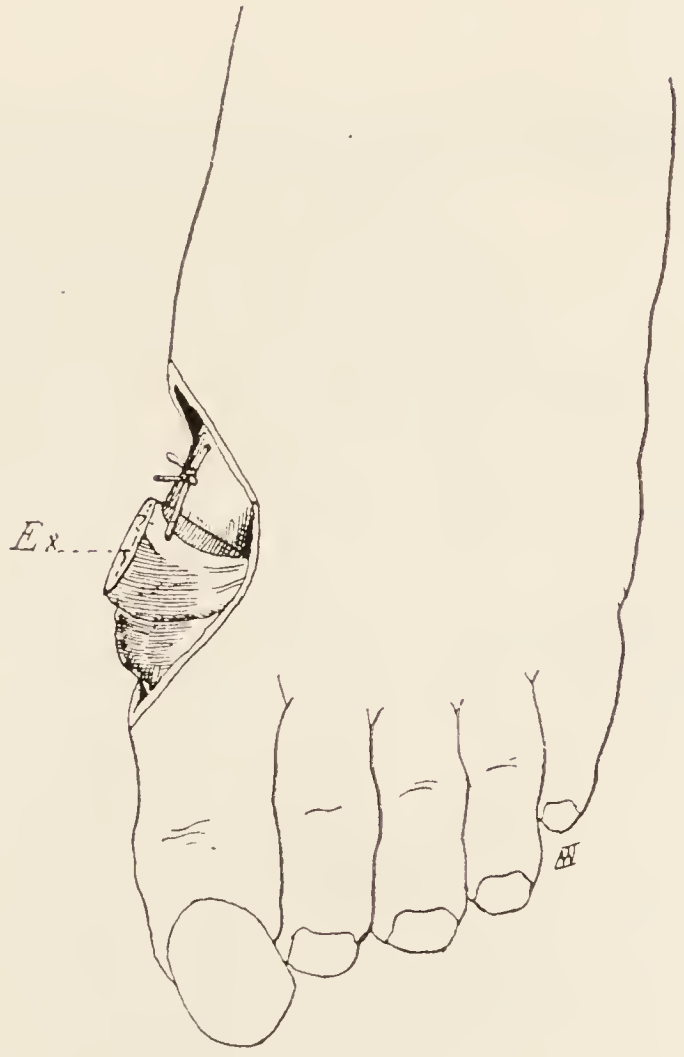


FIG. 481.—Bone operation completed and malposition of toe corrected. (*Young.*)

of one component of the first inter-phalangeal joint, with the interposition of fat, may be done, shortening the toe thereby and adapting the bony structure to the contracted tendons, or the extensor tendon may be severed and transplanted



FIG. 482.—Spur on the os calcis.

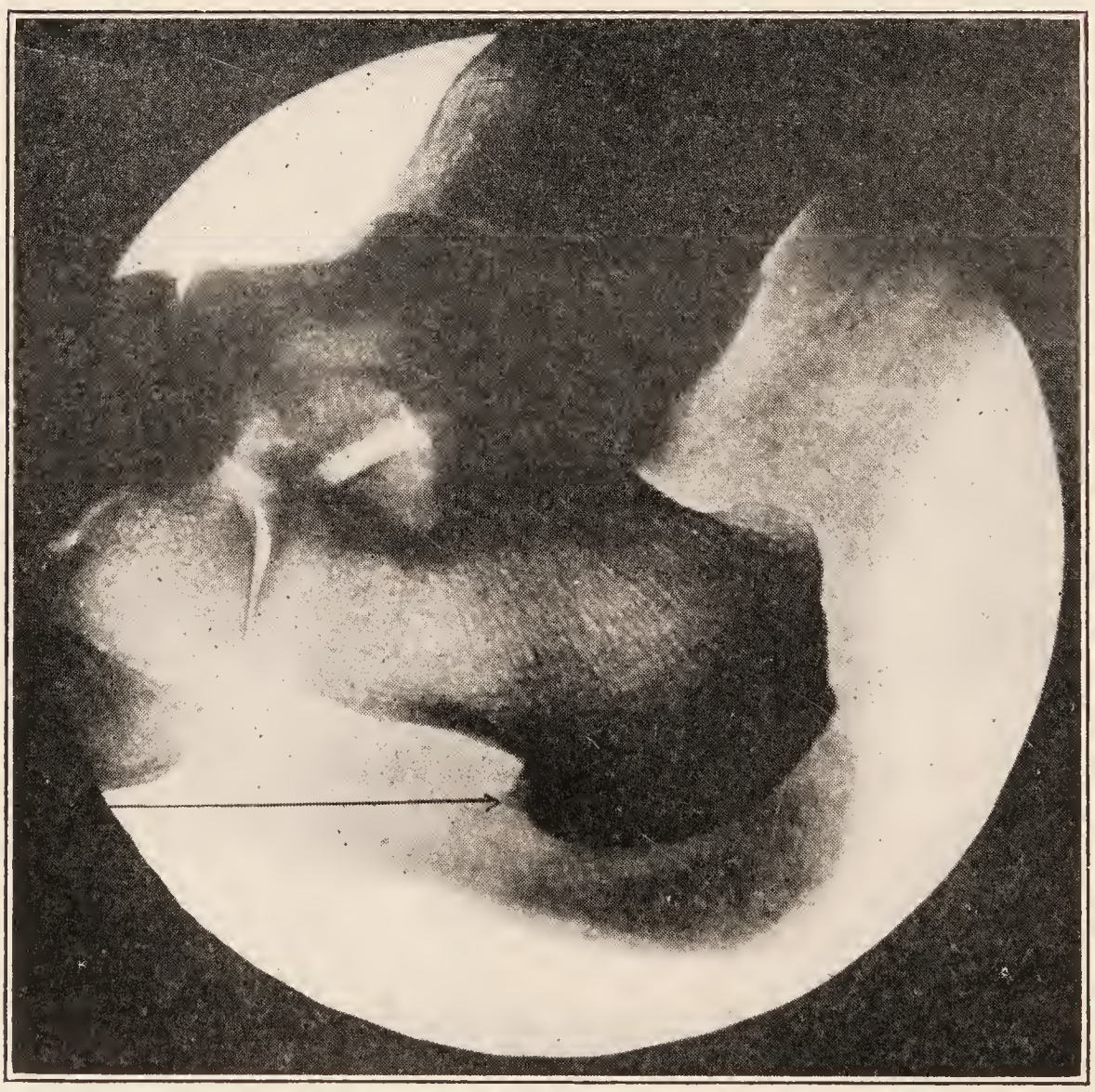


FIG. 483.—Exostosis on os calcis.

into the head of the corresponding metatarsal to pull it up and the flexor tendon may be severed and transplanted into the head of the first phalanx to pull it down.

4. **Claw Foot.**—In Claw foot, which in all probability is the result of Infantile Paralysis, especially in the unilateral variety, we have an unduly high arch and series of contracted toes like Hammer Toes.

Treatment.—The tendon transplantation recommended for Hammer Toe will be found of value in this condition together with tenotomy of the plantar fascia and flexors in the sole of the foot. As a rule, Claw foot is due to contracture of the plantar fascia, over-action of the short flexors, paralysis of the long flexors and over-action of the peroneus brevis and tibialis anticus. It is a difficult deformity to correct and tendon transplantation offers most.

5. **Deformity of the Little Toe.**—This is usually found as a similar distortion to Hallux Valgus and might be called Hallux Minimi Digiti or Over-Riding Little Toe.

Treatment.—The procedures recommended for Hallux Valgus apply equally well here, but being a smaller toe, sometimes by freeing the contracted ligaments on the inner side of the joint, one can restore the toe to the normal position, which can also be well held in place by a transplantation of the extensor tendon of the little toe to the outer side of the phalanx.

6. **Painful Heels.**—On the plantar surface of the heels a painful point is complained of by patients at times, with osteo-arthritis, more often with a history of Gonorrheal infection. The X-ray shows spurs or exostoses which must be curetted or chiseled off to cure. This is best done through an external incision or U-shaped incision on the plantar surface. Similar exostoses may occur at the insertion of the tendo achillis and require removal (Figs. 482 and 483).

CHAPTER XXII

INFANTILE PARALYSIS

Definition.

Infantile Paralysis occurs as a flaccid paralysis usually in early childhood, but isolated cases may appear in adolescence and young adult life. It appears at times in epidemic form leading to the belief in its infectious origin, but each year isolated cases are seen in which up to the present, the source of infection cannot be traced.

Synonyms.

Anterior Poliomyelitis and Teething Paralysis.

History.

In the Talmud, which dated back to the fourth century, are references to the application of apparatus for those deprived of the use of the lower extremities, which goes to show that in ancient Jewish surgery something was known in regard to paralytic conditions.

In the literature of India, in the "Susruta," estimated as having been written from 1000 B.C. to 700 A.D., appliances for paralyzed children are referred to.

Infantile paralysis is evidently not a new disease, but Wickman drew the attention of the medical profession to its epidemic nature in his valuable monograph on the Norwegian and Swedish outbreaks in 1905 and 1907.

No mention was made in the best textbooks 20 years ago of this epidemic character of the disease.

Until the New York epidemic of 2500 cases in 1907 was reported, epidemics of infantile paralysis were a rarity in this country. Since then there have been published accounts of epidemics occurring in Pennsylvania, Michigan, Minnesota, Virginia, Massachusetts, Nebraska, and Maryland.[1]

These reports are from comparatively few physicians, for, very unfortunately, as a rule, State Health departments do not require these cases to be reported. At the present time only 23 states require reports of this disease.

To neurologists and orthopaedic surgeons it is appalling as well as distressing to note the great increase in the numbers of these cases. The mortality is small, but the percentage of resulting paralysis is close to 90, as few cases recover absolutely. In the author's own experience, some 200 to 300 cases are treated annually at the Kernan Hospital and Dispensary for Crippled Children, alone, not counting those seen at the other hospitals.

Attention has been significantly called in this country to the greater number of cases seen in those localities where immigration has occurred from Scandinavia, which may have some bearing on the etiology.

Calmer first reported epidemic cases in this country in 1843, one case being an infantile hemiplegia seen by him at West Feliciania, La.

[1] R. T. Taylor, American Journal of Orthopaedic Surgery, November, 1917.

Anderson's report of the 1909 Nebraska epidemic of 279 cases in Polk County (there were 999 in the whole State) is most interesting and instructive. In his analysis 84 per cent. were under 10 years of age, fewer cases occurred up to the twenty-second year, and one patient was 36. Doctor. H. Winnett Orr, of Lincoln, Neb., personally collected 617 cases and lays great stress on the importance of quarantine. (Am. Jour. Orthop. Surg., February, 1911.)

In some large families only one child would be infected, and in others all but one or two. This seems dependent more on the qualitative virulence of the virus than on hygienic surroundings or feeble family resistance. We also see that the disease is more contagious at some times than at others.



FIG. 484.—Infantile paralysis. Paraplegic type. (*Young.*)

Anderson's cases had previously—as a rule—been unusually healthy children as is most often the case in the writer's experience, and lived in a invigorating sanitary country environment, the strongest child in the family being the one often most seriously afflicted.

Anderson believes that the disease was undoubtedly carried directly from case to case, but in certain instances by a third person. He cites as an example: Two families, A and B, lived some distance apart in the country. A girl from family B visited a family C, in which a boy was ill with infantile paralysis. On her return home she found children of family A visiting her home, who left shortly after her return. In five days her sister had the disease; a few days later a child in family A had it, and at intervals of a few days three other children in her own family had it—five cases carried by one person. He cites other similar instances. The carrying of contagion by intermediate people has also been reported on several occasions in the Scandinavian epidemics.

Flexner, however, has not been able to demonstrate the spontaneous transfer of this disease from infected to healthy monkeys by contact, although they are very susceptible to it by direct inoculation and it is highly fatal to them. He, however, distinctly states that this fact does not militate against the notion of

contagion in respect to the spontaneous disease in man, as monkeys are not naturally susceptible to this disease unless artificially implanted.

The Virus.

Flexner and Lewis, almost simultaneously with Landsteiner and Levaditi, have added to our knowledge of this disease in their discovery that the infectious agent is an extremely minute microorganism or unit. It is ultramicroscopic and on passing through the pores of the finest, densest, porcelain Chamberlain filters retains its potency. This has been brought out by experimental research on monkeys; and attempts to implant the disease on other animals, including guinea-pigs, rabbits, rats, mice, dogs, cats, sheep, cows, goats, pigs, chickens, pigeons and the horse have failed. Flexner thinks, however, that the paralysis seen in poultry, the dog and horse are due to a cause peculiar to the species infected. This is especially interesting, as in the epidemic in Michigan, in 1907, Griffin reported that many pigs and chickens were also affected. Krause, also, in the Westphalia epidemic of 1908, reported a coincident great mortality among chickens.

In consultation recently the writer saw a child, in the acute stage, who had played five days before in a chicken yard where many of the fowls showed paralytic symptoms. The child did not have any chicken nor eggs to eat at the house she was visiting.

A colleague told me of hearing of two children who had eaten chicken and their dog had eaten the bones, and all three were paralyzed shortly after.

Flexner is inclined to believe that the virus gains access to the cerebrospinal axis by means of the nasal mucous membranes and lymphatics through the cribriform plate of the ethmoid. He also thinks it is eliminated by it.

Intraperitoneal injection of monkeys with spinal cord material from a child who died of paralysis reproduced the disease, but the cord from such infected monkeys would not reproduce the disease when introduced intraperitoneally in other monkeys.

The disease could also be reproduced by injection into the circulation, the subcutis, spinal canal, large nerves and certain mucous surfaces, from human to monkey. Similarly, if peristalsis is minimized by opium the introduction of comparatively large quantities of the virus into the stomach and intestines are required to reproduce the disease.

On examination of at least 90 per cent. of the Kernan Hospital's histories the writer is quite within the limit in saying that gastro-enteric symptoms so preponderated at the onset that it seems suggestive that the systemic infection started there, and in the human subject there are rarely symptoms suggestive of a coryza at the onset or decline. William Neill, in our analysis of 100 consecutive histories of anterior poliomyelitis, found only 3.1 per cent. with throat and nose symptoms at the onset. At the same time we must bear in mind the frequency of the reflex gastro-enteric symptoms of central origin at the onset of other infections, but acid, sour, frequent, semi-liquid, fetid stools persist often for weeks.

Pathology.

Provost, in 1865, gave quite a good account of the lesion in this disease. Congestion and hemorrhage are seen as gross lesions in the grey matter in the

spinal cord and medulla, but not exclusively confined to the anterior horns. Flexner has added much to our knowledge of the pathology of anterior poliomyelitis.

Microscopically, the lesions are found in the brain and cord, but more markedly in the latter than the former, and in the grey matter and membranes of the cord more than in the white matter. No part of the cord and medulla escapes, but the lesions are more extensive at the levels of the paralyzed groups. Mononuclear infiltration forming collars around the blood-vessels preponderate, and in the membranes of the cord there is an interstitial invasion and no exudate. There is edema of the perivascular spaces and sometimes hemorrhage. Both he anterior, posterior horns and commissures are involved, but chiefly the trst named, as the central arteries enter the anterior median fissures (Fig. 485)



FIG. 485.—Anterior poliomyelitis in adult, showing distribution of round-cell infiltration within gray and white matter. (*Spiller.*)

That the cervical and lumbar enlargements have a more abundant arterial blood supply accounts for the greater severity of the lesion at these points. Both the nerve cells and nerve fibres in the inter-vertebral ganglia may be the seat of degeneration and necrosis. Severe degeneration and necrosis are not recovered from and lead to permanent paralysis, but edematous conditions and anemic occlusion of vessels from perivascular infiltration explain the transient paralysis. Cerebral involvement may lead to a facial palsy, but is very rare.

Serious degenerative changes in the medulla result in respiratory distress or death in the bulbar form of this disease. Sachs regards *infectious meningo-encephalomyelitis* as a more correct name than anterior poliomyelitis, since the pathology has been more carefully worked out and the distribution found more extensive.

Predisposing Causes.

In contrast to acute cerebro-spinal meningitis which appears in winter and early spring, anterior poliomyelitis more commonly is a disease of the summer and early fall, and is most frequently noted during an especially hot spell. As a rule, dry summers seem to have a tendency to lead to more cases than wet ones. In my series, Neill found January, 5 per cent.; February, 6 per cent.; March, 9 per cent.; April, 7 per cent.; May, 9 per cent.; June, 8 per cent.; July, 8 per cent.; August, 8 per cent.; September, 9 per cent.; October, 15 per cent.; November, 10 per cent.; December, 6 per cent.

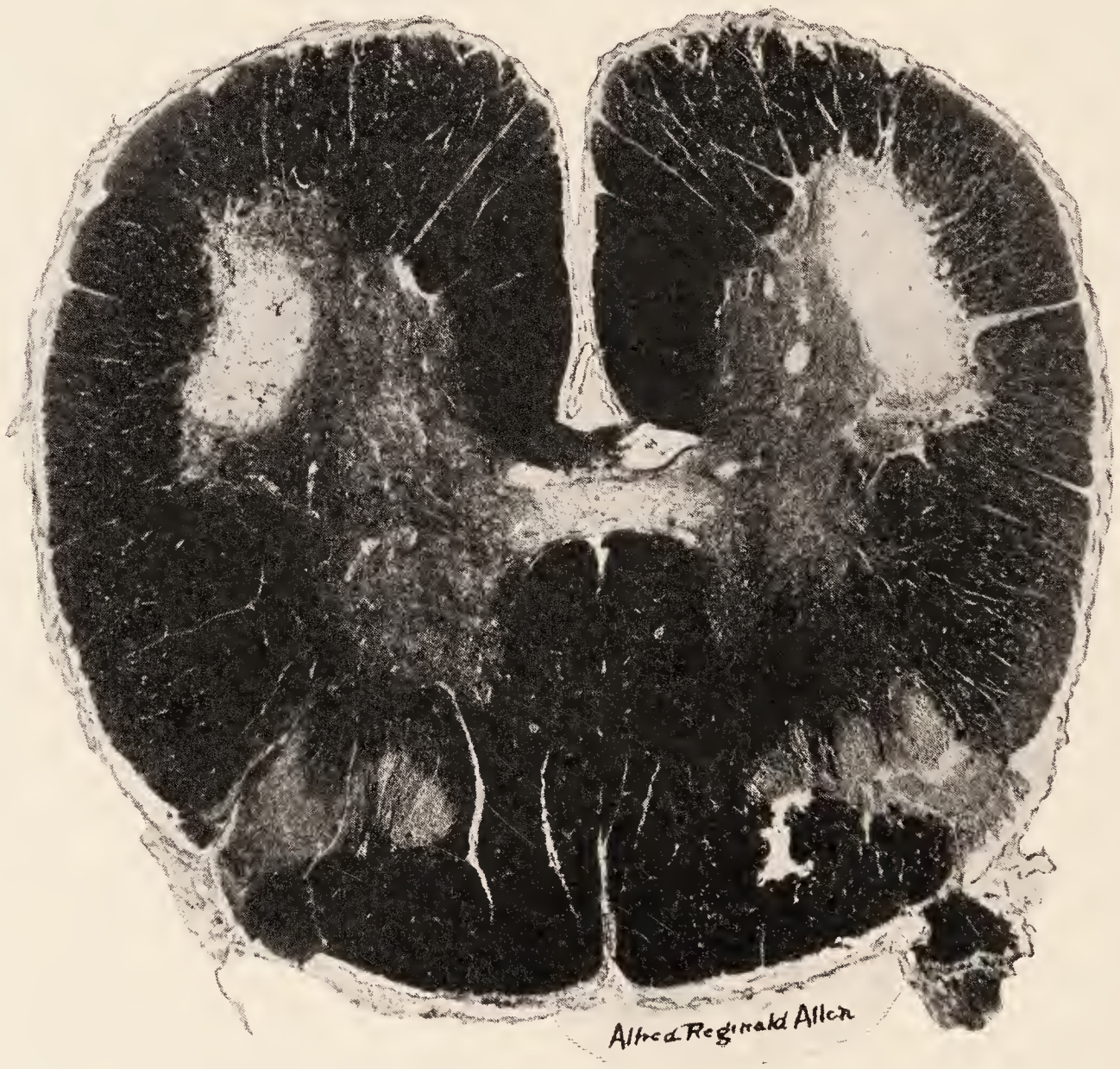


FIG. 486.—Poliomyelitis in adult of sixty. (*Young.*)

The monthly incidence in the Baltimore Epidemic in 1916 was:

	STATE	CITY		STATE	CITY
January	2	0	July	10	3
February	1	0	August	65	37
March	2	2	September	104	71
April	0	0	October	121	74
May	0	0	November	43	17
June	0	0	December	5	2

In the city, with an estimated midyear population of 589,625, there were 206 cases, or a morbidity rate of 34.9 per 100,000. There were 70 deaths, giving a death rate of 11.9 per 100,000 population and a fatality for the disease itself of 33.8.

One hundred and forty-one acute cases were treated in hospitals, being transferred as soon as recognized and practicable by the health department.

There were 289 white cases and 64 negroes stricken.

Fifty of the 70 fatal cases were autopsied, which again emphasized the enormously edematous cords and *involvement of the lymphatic elements in the intestines and adjacent mesentery.*

In many of the histories obtained by the writer, chilling of the body seemed to play some part, as parents after an exceedingly hot day would take a young child, insufficiently protected, to "cool off" in a buggy ride, trolley or motor car. Some children, who have gone to sleep on the grass or on the basement floor, were soon seized by an attack of paralysis.

Symptoms.

Premonitory symptoms are very probably due to lepto-meningeal irritation or implantation of the virus, and are usually present one to three days before the acute symptoms begin. They consist of more or less rigidity of the spine and neck, and Kernig's sign with unequal rigidity in the two legs. At this time the knee reflex may be increased only to disappear entirely after the acute stage is reached. Sometimes there is a slight weakness in one or both legs. Acute symptoms appear in from 4 to 14 days after exposure in the epidemic form, but in the majority of the so-called sporadic cases seen, it is next to impossible to trace the source of infection and period of incubation.

1. **Nervous Symptoms.**—The symptoms divide themselves into cerebral. bulbar, spinal and neuritic types, depending upon the region chiefly involved, In the cerebral form convulsions, delirium and drowsiness are present, but this type is rare. In the bulbar form we see the respiratory distress, and 75 per cent. of these constitute the rapidly fatal cases of this disease. The neuritic types are those presenting marked hyperesthesia and severe pain in the extremities along the larger nerve trunks especially, and even also in the chest and abdomen, so that the slightest movement, jarring or moving of the bed clothes produces suffering.

2. **Temperature.**—The onset begins with slight fever (99–101° F.) the first day, with flushed face, intense headache, backache and increased unilateral Kernig's sign. Except in the mildest cases, the fever on the second day is highest, but rarely goes to 105° usually not being over 102°. The pulse ranges from 120 to 140, but is usually of good tone and well sustained, except in the bulbar type.

3. **Rigidity.**—Spasticity in the neck, spine and legs is more marked the second day. Tremors and clonic movements may be present, but sleep is quiet, as there is more or less drowsiness.

4. **Gastro-enteric Symptoms.**—Nausea and vomiting may be the first symptoms noted and lead one to think the trouble is primarily gastro-enteric, but these symptoms may be central in origin. *Constipation* of the bowels is common at the onset, with a diarrhoea later of *very offensive putrid stools.* Of very nearly as great frequency one finds *retention of urine*, so that catheterization may have to be resorted to, though this is rarely necessary.

5. **Flaccidity.**—On the third day the fever abates, and on that day or the day following the paralysis appears, converting the previously spastic limb into a flaccid one. With the subsidence of the fever there may be some sweating. The headache and backache disappear, but with the paralysis the hyperesthesia begins, if the case is of the neuritic variety.

There are also shooting neuralgic pains, at times lasting for a few seconds or a few minutes and recurring several times an hour at first. These shooting pains disturb the sleep, probably due to the child moving in the sleep. They cry out much as those who have acute tuberculous articular disease, with a characteristic "night-cry."



FIG. 487.—Paraplegic type of anterior poliomyelitis. (*Young.*)

6. **Rash.**—Occasionally there is an erythematous rash, not so fine as scarlet fever and less spotted than measles. Large rose spots may occur on the body at times, later being pigmented. In a very few cases purpuric spots appear in the lower extremities.

7. **Paralysis.**—A severe general paralysis at the onset may clear up in a few days, weeks or months, leaving paralyzed only those muscles that receive innervation from the necrosed segments of cord. Paralysis of the legs is much more common than in the arms. The most frequent permanent leg paralysis is seen in the extensors of the toes and tibialis anticus. Next in frequency is the quadriceps extensor of the leg, and often associated with it is paralysis of the adductors, in my experience (Figs. 487 and 488).

At times the psoas and iliacus are also involved, but usually only in conjunction with the other lower leg muscles.

Of the hamstrings the biceps escape most often and the sartorius of the anterior thigh group is equally fortunate. The calf muscles and flexors of the toes are not nearly so frequently involved as the anterior group. The glutei and quadratus lumborum on one or both sides are often involved.

As a rule, if a paraplegia exists there is frequently entire dissimilarity on the two sides. Often one side will clear up in 6 to 12 months.

Of the contracture deformities seen, flexion and outward rotation of the thigh and flexion of the knee are more common than the reverse, owing to the greater frequency of paralysis in the antagonistic groups, although Sever, at the Children's Hospital, Boston, finds adductor paralysis less frequently than we do.



FIG. 488.—Quadripedal efforts at walking in infantile paralysis. (*Young.*)

Of the foot deformities in their order of frequency may be named in my experience talipes equinus, talipes valgus or paralytic flat-foot, talipes equino-varus, talipes cavus and talipes calcaneus. Similarly in the arm the distribution of the paralysis is asymmetrical, depending on the necrosis in the segments involved, but the deltoid, supra- and infra-spinatus, triceps, biceps, supinators, extensors of the fingers, thenar and hypothenar groups suffer, in the order named, most frequently (Fig. 489).

The quadratus lumborum, serratus magnus and erector spinae, if the back muscles are involved, most often suffer, while the pectoralis major is the anterior

muscle of the thorax most commonly paralyzed. The abdominal muscles, the diaphragm, sterno-mastoid and trapezius are among those most rarely affected in the writer's experience (Fig. 490).

Monoplegia of one leg is the commonest end result; next in frequency is paraplegia, then hemiplegia, then paraplegia with some trunk involvement, and, last of all, both upper and lower extremities.

8. **Atrophy.**—Atrophy becomes marked in from one to six months after the fever and may be extreme. This atrophy involves not only circumferential measurements of the limb, but the bones are also affected in length and circumference. The latter is shown by the X-ray. Delayed use of the limb in neglected cases where braces or operative treatment have not been employed in young children leads to the most extreme degree of shortening seen, amounting to three or four inches or more (Figs. 491, 492 and 493).



FIG. 489.—Paralysis of extensors, also thenar and hypothenar groups from infantile paralysis.

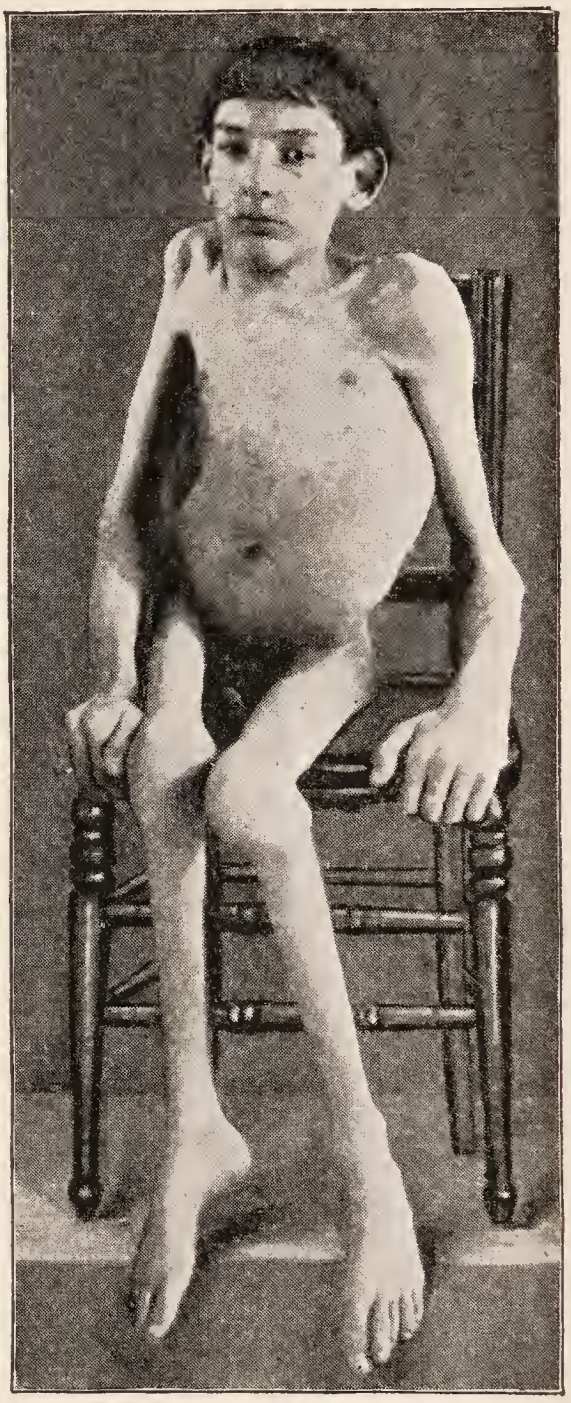


FIG. 490.—Severe paralysis of arms, spine, legs and abdominal muscles. (*Young.*)

Diagnosis.—Kernig's sign of an asymetrical type, constipation, retention of urine, spasticity of spine and neck, fever of short duration with subsequent flaccid paralysis, render diagnosis simple, but it may be confused with (*a*) "ptomaine poisoning" or auto-intoxication with vomiting and constipation, (*b*) rheumatism, (*c*) typhoid fever, (*d*) la grippe, (*e*) cerebro-spinal meningitis, and (*f*) Acute Encephalitis Lethargica or "sleeping sickness." The first four should not present any serious difficulties and lumbar puncture would clear up the diagnosis of the last two. The presence of brief fever, unilateral Kernig's sign and flaccid paralysis should render diagnosis obscure only a day or two. In addition to the early symptoms named, Flexner has shown that the cerebro-

spinal fluid obtained by lumbar puncture shows characteristic changes in the acute stages which are of diagnostic value. There may be a slight increase in the amount and pressure of the fluid during the incubation period with progressive increase in the cellular elements, especially the lymphocytes, so that at the height of the disease the fluid previously clear becomes opalescent and undergoes a spontaneous coagulation from excess of protein. As the disease abates it reassumes its normal clearness and noncoagulability. The opalescent fluid is potent in reproducing the disease while the clear cerebro-spinal fluid is not.

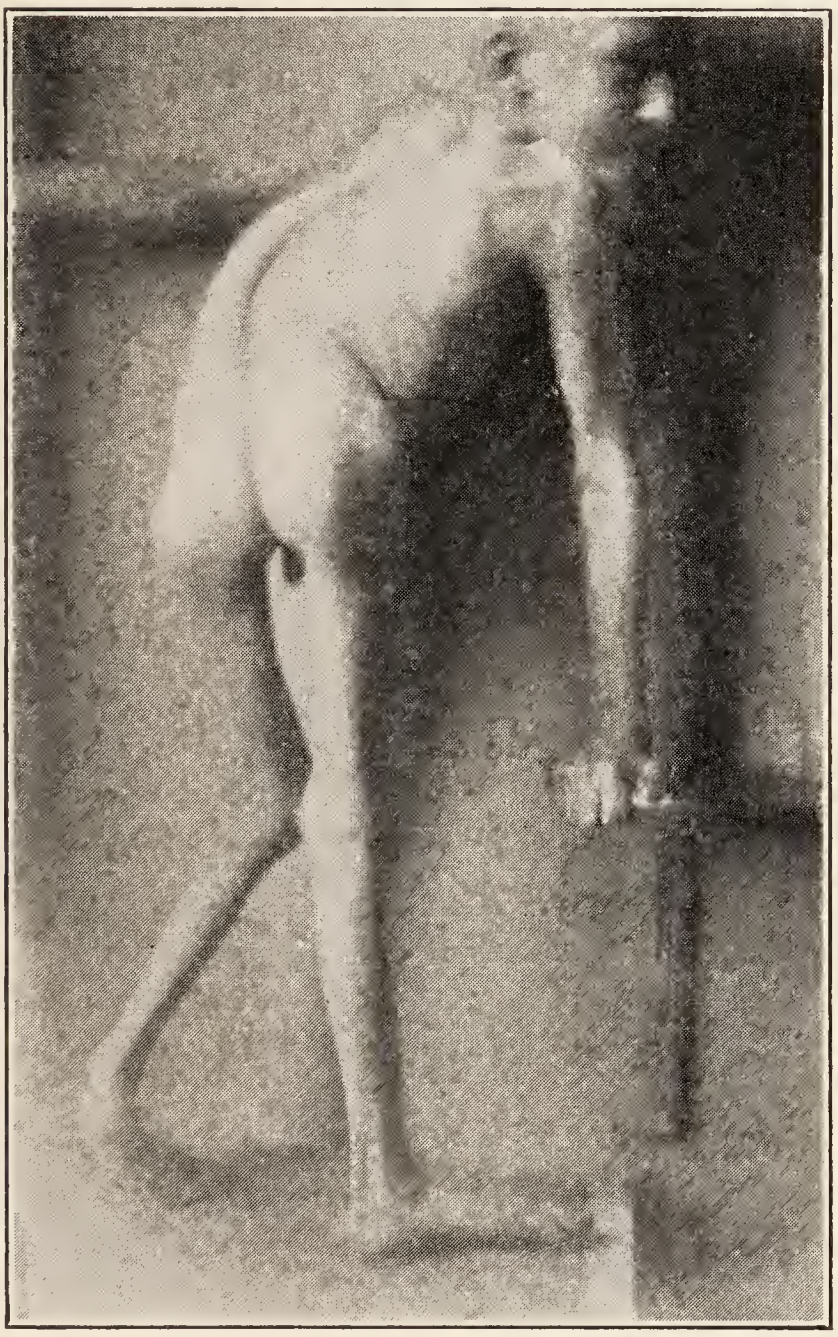


FIG. 491.—Extreme anterior poliomyelitic case involving the spine, abdomen and legs.

Treatment.—With the increasing numbers of cases of anterior poliomyelitis and the partially accepted discovery of Flexner as to the mode of entry together with the sad lessons learned from recent epidemics of this disease—if a physician is called to see a child in the summer, with vomiting, constipation, Kernig's sign, retention of urine, rigidly of the neck and spine and moderate fever, isolation is desirable. If a mistake is made in diagnosis no great harm is done, if the situation is explained in advance to the parents.

There is no question that it is the duty of State Boards of Health to insist upon the immediate reporting of all cases of infantile paralysis. Neglect of these points may be responsible for the alarming increase in this disease. In the writer's own series four times as many cases were seen in 1910 as in any of

the previous 15 years since the Kernan Hospital for Crippled Children was established.

There seems to be undoubted clinical and experimental data at hand, according to Flexner,[1] Anderson and Frost,[2] Rosenau,[3] Howard and Clark,[4] and others that Stomoxys calcitrans, the stable Fly, Musca domestica or common house fly, and the bedbug may carry the infective agent, the patient's bed should therefore be screened and scrutinized.

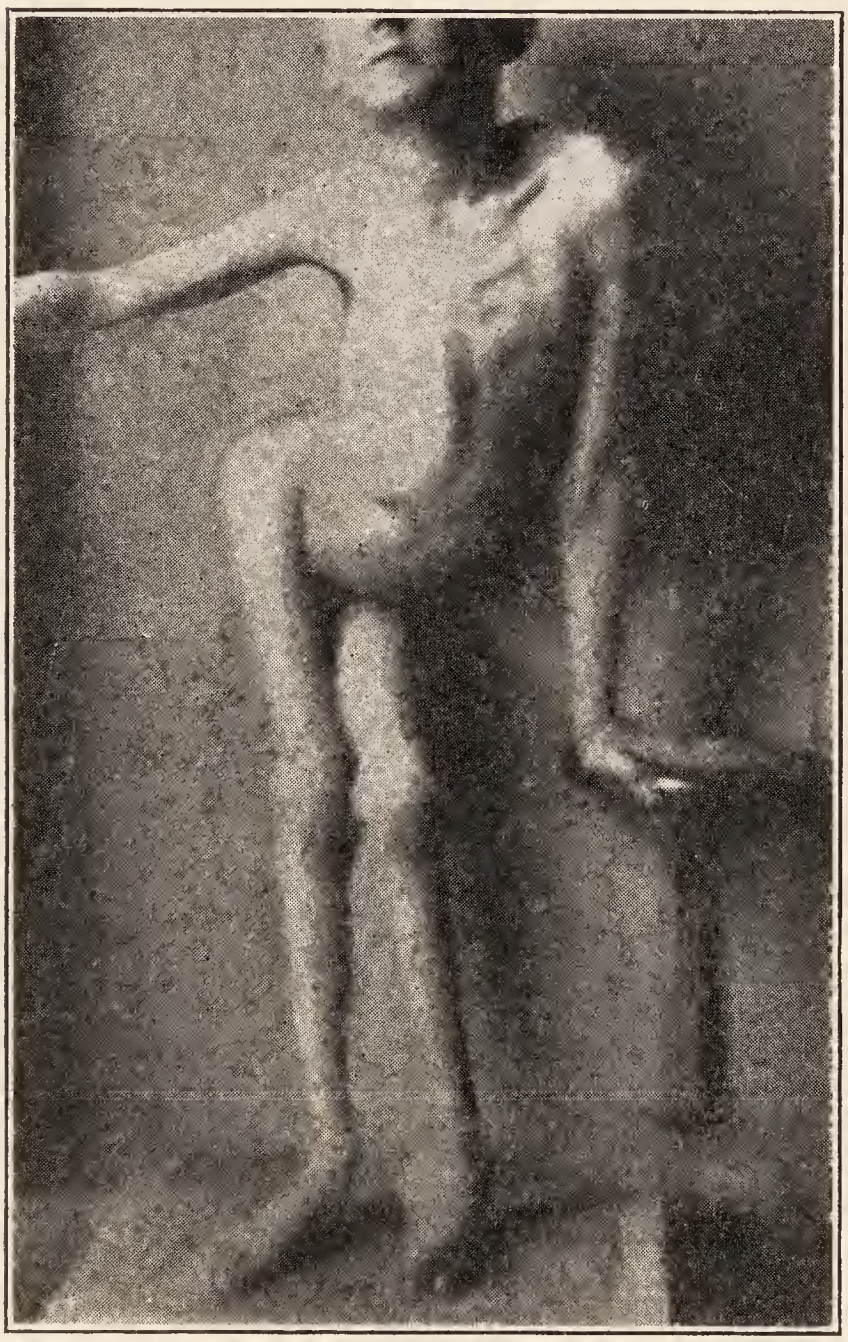


FIG. 492.—The same, front view.

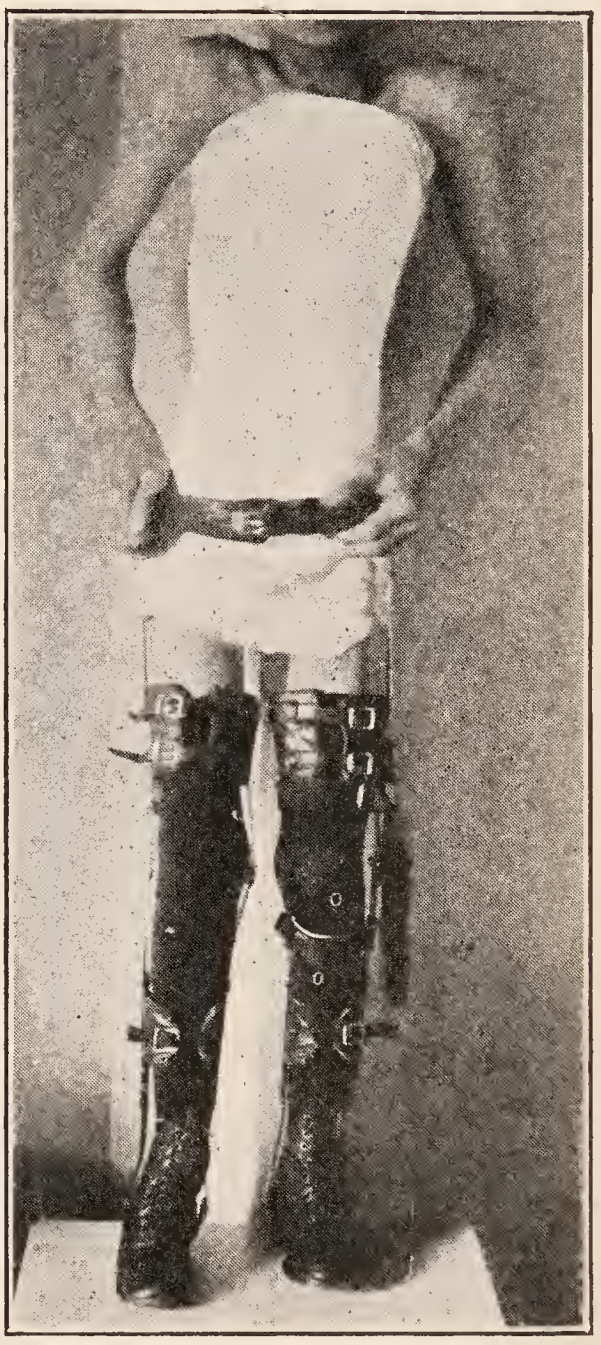


FIG. 493.—The same, supported by plaster jacket and braces.

Langhorst[5] has presented evidence showing the danger of domestic animals, notably dogs, acting as carriers or even being subject to the disease, and such

[1] Flexner, Mode of Infection in Epidemic Poliomyelitis, Jour. A. M. A., Oct. 12, 1912 vol. lix, page 15.

[2] Transmission of Poliomyelitis by Means of the Stable Fly (Stomoxys Calcitrans). Public Health Reports, Oct. 25, 1912, page 1733.

[3] Rosenau and Brues, Some Experimental Observations upon Monkeys Concerning the Transmission of Poliomyelitis through the Agency of Stomoxys Calcitrans, Monthly Bull., Mass. State Board of Health, Sept., 1912, vol. vii, page 9.

[4] Howard and Clark, Experiments on Insect Transmission of the Virus of Poliomyelitis, Jour. Exper. Med., Dec., 1912, vol. xvi, page 6.

[5] Langhorst, Possible Transmission of Poliomyelitis through the Dog, Jour. A. M. A., Dec. 28, 1912, vol. lix, page 26.

pets should be excluded from the sick room. Flexner, Clark, and Fraser[1] demonstrated the virus from the healthy mucous membrane of the upper respiratory tract in an adult, who had been exposed in the care of a case. Several physicians have brought their own children to me for treatment, feeling that they had carried home the infection.

These facts should teach us that those coming in immediate contact with an acute case of poliomyelitis should protect their hands, clothing, and respiratory tract in a proper manner, lest they become unwilling and unwitting carriers of the disease. Thus also the number of attendants should be minimized.

Lucas and Osgood[2] have found the virus in the nasal secretions four months after the attack. This should point to frequent spraying and douching of the nasopharynx with proper antiseptic solutions, even after the physician deems rigid isolation no longer necessary.

When a diagnosis is definitely established the case should be at once reported to the State Board of Health.

Treatment Proper.—The treatment should naturally be separated into three periods: (*a*) the febrile stage, with the development of the paralytic distribution and hyperesthesia; (*b*) the stage of repair and recovery in part or whole of the motor paralysis; and (*c*) the stage where the restoration of power in certain region is as complete as it is going to be, and deformities, flail joints, etc., require surgical intervention.

(*a*) **Febrile Stage.**—The author[3] places elimination in the first place, as the nasopharynx, bowels, and kidneys serve chiefly to free the system of the virus.

Alkaline and antiseptic sprays should be used in the nose and pharynx every two hours and the patient should expectorate into a carbolic solution. Handkerchiefs should be similarly cared for.

Elimination by the bowels, a difficult thing to accomplish on account of the atony, must be gained by broken doses of calomel and soda followed by one or more doses of castor oil, if the first doses of oil are vomited. Enemata, first of cotton seed or olive oil, followed, if necessary, by soap suds, then by glycerin and epsom salts, of each two ounces, and water, a pint, will be effectual; or turpentine, hydrogen peroxide, oil, and soap suds may be used. When the bowels are moved, usually by the second or third enema, the bladder will be emptied at the same time voluntarily. Catheterization is rarely necessary. Hot wet packs will stimulate the skin to action as well as relieve hyperesthesia. The same may be said of hot baths. Drinking freely of water is to be encouraged to promote elimination by skin and kidneys. Proctoclysis (Murphy's) is helpful with the same end in view.

Cold compresses or ice caps should be kept on the head. Some gain may be experienced from counterirritation over the spine by tincture of iodine or mustard, short of blistering, in the acute stage of paraplegia, but as the patient must needs lie on the back, care should be taken that this is not carried too far.

[1] Flexner, Clark and Fraser, Epidemic Poliomyelitis. Passive Human Carriage of the Virus of Poliomyelitis, Ibidem, Jan. 18, 1913, vol. lx, page 3.

[2] Lucas and Osgood, Transmission Experiments with the Virus of Poliomyelits, Ibidem, May 24, 1913, vol. lx.

[3] Taylor, Our Present Knowledge in Regard to Infantile Paralysis, Amer. Jour. of Surg., Nov., 1911.

Hexamethylenamine, given by mouth, which rapidly appears in the cerebrospinal fluid, may be used to advantage in doses of one to two grains every two hours for the first three days. It was first recommended by Cushing and Crowe[1] of Baltimore. Adams and McClanahan, of Nebraska, speak well of it. Anderson, however, says in his 279 cases it was given with uncertain results. Fraser[2] in a study of twenty-two acute cases at the Rockfeller Institute, gave 0.3 gram of hexamethylenamine three or four times a day. In two instances after five and six days respectively and the administration of five and six grams, hematuria appeared, but cleared up immediately on discontinuing the drug. One child, aged three years, received 16.8 grams in a period of four weeks. Fraser says: "In no instance did this treatment appear to cut short the acute stage and in no instance was there any evidence of more satisfactory or more rapid recovery in the paralyzed parts." However, Fraser feels that a larger number of cases should be critically analyzed before a decision is reached in regard to hexamethylenamine.

In 1912, epinephrin or adrenalin was used intraspinally in doses of 1 to 3 c.c. of a one in 1000 solution by Clark[3] with equal parts of salt solution in a study of experimental poliomyelitis in eight monkeys. He reached no definite conclusion as to its value.

Nütter[4] reported the use subdurally of an injection of the serum from recovered cases. Although no conclusions were drawn, this or similar work will eventually be of value in leading up to a remedy or a means of ameliorating the infection and aborting the disease.

Lumbar puncture is often of value, not only for diagnosis, but for relief of pressure symptoms, especially in bulbar symptoms of respiratory failure, such as cyanosis, shortness of breath, pallor, and anxious facies. Lumbar puncture should be done with the most scrupulous asepsis between the third and fourth lumbar vertebrae, with the child on the side and the spine well flexed. The knees should be flexed and a bandage passed under them and around the neck to prevent sudden extension of the spine, which might break the needle. High fever is best treated by cold sponging and not by coal tar products. Oxygen inhalation may be of some slight transient help in cyanosis. In very severe respiratory distress, the lungmotor or artificial respiration may give temporary relief. The warm bath and gentle passive movements while in the bath have helped the neuritic pain.

The author feels he has *repeatedly seen not only the immediate relief of headache and restlessness* as a benefit from lumbar puncture but with the immediate introduction of blood serum from recovered or convalescent cases and adrenalin in the proportion of 9 cc. of the former to 1 cc. of the latter in 10 cc. doses, repeated 2 or 3 times (every other day), *the nearest approach to early specific treatment.* By using this method and when fortunate enough to secure cases,

[1] Crowe, Johns Hopkins Hosp. Bull., 1909, vol. xx, page 102.

[2] Fraser, Clinical Observations on Ninety Cases of Acute Epidemic Poliomyelitis, Rockefeller Institute Reprints, 1915, vol. xxi, page 514, and Amer. Jour. Med. Sc., July, 1914, vol. cxlviii, No. 1, pages 1–22.

[3] Clark, Jour. A. M. A., vol. lix, page 367.

[4] Nutter, Comp. rendus Soc. med de biol., 1911, vol. lxx, page 625.

when first taken and with widely distributed paralysis a marked clearing up, improvement or cure was a result.

Too great stress cannot be laid upon the importance of rest in the acute stage of poliomyelitis. In quite a percentage of the more severe cases, there is marked hyperesthesia, tenderness to touch and motion, which, however, is to be distinguished later on from the stiffness of the joints due to prolonged immobility or fixation. This hyperesthesia is best met by a comfortable mattress, even an air mattress, or large superimposed pillows. Each arm should be supported on a pillow in such a way as to prevent dragging down on the deltoid and capsule of the shoulder, as this region is affected in nearly one-third of the cases (Fraser) and the outcome depends largely on adequate support and the avoidance of drag on the deltoid, which would further impair its power as will over-action of the pectoralis major, which usually escapes paralysis. This support and abduction in convalescence must also be cared for by a sling, axillary pad, or light abduction wire splint to keep the humeral head and glenoid cavity in as close apposition as possible when a child is able to get up. The legs are preferably to be kept straight in the line of the body, but discomfort is frequently complained of in this position, and the knees must be supported semiflexed by a pillow and at times rotated inward in paralysis of the inward rotators and adductors. Such positions should not be continued for any length of time and must be frequently changed, as contractures and malpositions will become fixed.

Toe drop, not only from paralysis of the anterior group of leg muscles, but even from the weight of the foot or of the bed clothes, will produce an equinus deformity in a few days unless we are most careful to prevent such a position. A wire or frame cradle should support the bed clothes, and a right angled wood, wire, or plaster of paris shell should support the foot at right angles with the leg or even slightly dorsally flexed.

Many advocate fixation of the spine in a light plaster of paris jacket and similarly the extremities in casts. These hamper gentle massage which is soothing, especially in conjunction with the warm bath. I prefer a plaster jacket and plaster casts, from which the anterior portions have been cut away, so that the patient lies in what might be called shells. Lange[1] recommends the light celluloid braces for the extremities and concurs with Oppenheim in using the solid plaster jacket, which he advocated in 1909. Sever[2] calls attention to the frequency of hip dislocation from over-action of the adductors with paralysis of the adductors. This must be provided against. Hot packs and applications, baths of hot air or water, aspirin, and opiates may all be required, in addition to rest and fixation for the relief of the hyperesthesia, but lumbar puncture usually relieves this and is the best of all remedies, at the onset with convalescent serum injection.

(*b*) Convalescent stage. To yield to the anxiety of both the physician and distressed parents to get the paralyzed child on its feet again, is a mistake in the early stages of impaired muscle function, and it is safer to prolong the rest

[1] Lange, Amer. Jour. Ortho. Surg., vol. viii, page 8.

[2] Sever, The Causes and Treatment of Paralytic Dislocations and Subluxations of the Hip Joint, Boston Med. and Surg. Jour., Aug. 31, 1911, vol. clxv, page 9.

and freedom from joint strain for a month or six weeks rather than get the child up at the end of the fever, which only in unusual cases lasts more than a week. Judson[1] goes to the extreme of advocating bed treatment, including massage, later passive exercises, etc., as long as 18 months.

As there is no known remedy to hasten repair in the cord, unless it be the convalescent serum referred to, our efforts must be addressed to improvement of the power remaining in muscles or parts of muscles that still have central connection and some control, and of the circulation.

Physiotherapy.—Overzeal may do harm, however, by too prolonged or too deep massage or excessive manipulation to start with. Lange,[2] Lovett,[3] and others counsel against this. Lange warns against "rough, hard and deep stroking massage." The best routine to follow is, perhaps, a warm air bath by a baker of electric or gas heat at a temperature not to exceed 250° F., or warm bath, gentle massage for 20 minutes to loosen contractures in muscles or stiffness around joints, then electricity, and finally such guarded and graded exercises as are deemed safe. This course of treatment may be given twice daily, or only three times a week, depending on the degree of fatigue.

The slowly interrupted Faradic current effected by the pendulum attachment should be applied over the origin and insertion of the weakened muscles not only to stimulate circulation and nutrition, but to retain any slight remaining power of contraction. Children tolerate this better than the buzzing variety of Faradic, and this is an important consideration with babies and timid young children. In the long run it has been more useful to me than the galvanic or sinusoidal. With the galvanic current in paralyzed muscles we obtain the reaction of degeneration, or a stronger contraction with anodal closure than with cathodal, the reverse of the normal behavior; but this is of diagnostic rather than therapeutic value.

These paralyzed limbs are cyanotic and cold in winter, and children find great comfort from the gas or electric baking ovens which we usually employ before the massage and electricity, for the skin is moistened thereby and the electricity is more efficient in producing muscular contraction when any vestige of life is left, than when the skin is dry.

Frauenthal[4] advocated high frequency currents, even in the earliest stages in the belief that it causes a diminution of the edema in the spinal cord, but satisfactory demonstration of its efficiency is lacking. Electricity is simply to be regarded as an adjunct to the massage and exercises, and should we have to do without one, electricity is certainly the least important.

Muscle Training.—The desideratum is active exercise or voluntary effort to use any given muscle or group or muscles and is of the greatest importance, no matter how slight, as it stimulates central control. The more the child tries, the more successful the treatment. Rarely can active motions be accomplished at first, and passive motions of every affected group are of importance at each treatment. Then come assisted active motions and finally resisted active

[1] Judson, Annals of Gyn. and Ped., Oct., 1907.
[2] Lange, Amer. Jour. Ortho. Surg., vol. viii, page 8.
[3] Lovett, Trans. Med. and Chir., Faculty of Maryland, 1915.
[4] Frauenthal, Jour. A. M. A., 1913, vol. lxi, page 2219.

motions. Even if a limb seems powerless, every possible active motion must be tried actively, assisted if need be, by the masseuse, as Wright says,[1] and *guided by the physician or surgeon.*

The masseuse must be especially taught what muscles are paralyzed, or partially paralyzed and what antagonistic muscles still possess normal power and must be well stretched to prevent contracture, and thereby give the weakened muscles a chance to regain their tone. If this is done at the start and persisted in, no contractures should occur which will require tenotomy or myotomy later.

As far as possible the exercises should be made a game or source of play to the child, to avoid irksomeness and tedium so that each day he can "play longer." With this idea in view, floating toys to be pushed around in the bath, balloons, marbles, and suspended balls help.

It must be borne in mind that the muscles do not all regain power or tone with equal rapidity, depending, of course, on the situation and extent of the central lesion or edema, and one group may still be very weak while its antagonist has materially recovered, so that in this state we must watch for contractures and anticipate them by treatment.

Systematic treatment, intelligently carried out, shows by comparison with neglected, ignorantly handled cases.

Braces.—As soon as all acute symptoms subside, if the child cannot bear weight on either one or both limbs without producing distortion, proper braces and shoes must be designed and prescribed by the surgeon to meet the requirements of the individual case. No ready made brace or haphazard application at a brace shop should be considered any more than ready made eyeglasses for the visually defective (Figs. 494 and 495).

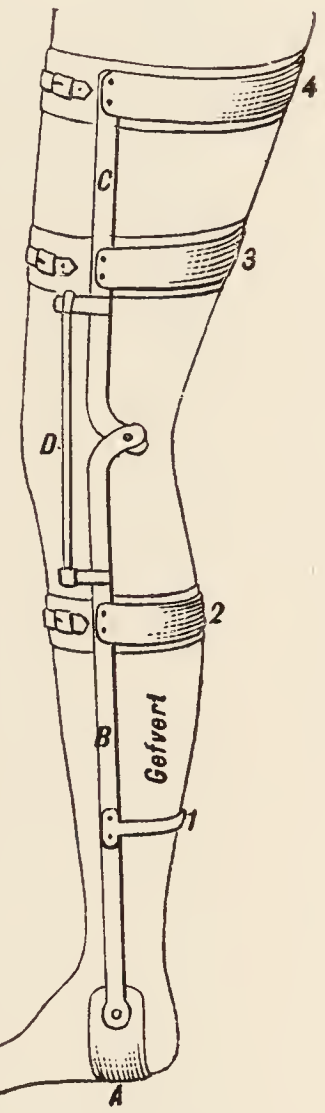


FIG. 494.—A type of paralytic brace for support with involvement of both leg and thigh muscles.

A, Steel stirrup attached to steel sole plate or shank of shoe; *B*, steel upright to knee joint with calf bands 1 and 2; *C*, steel upright from knee joint upward with thigh bands 3 and 4; *D*, spiral spring to supplement weakened quadriceps. Note centre of motion at knee in brace is thrown well back. (*Young.*)

Get the child on its feet as soon as is safely possible, as no stimulus is so good as an effort at assisted physiological use. Further, we orthopaedic surgeons are all agreed that nothing stimulates growth, power, and development of both bone and sinew more than physiological functional use, and yet we meet those—in the profession, too—who aver that braces produce only atrophy, and that it is much better to let the child get along, as best it can without them, in vicious positions. This many do, with resulting distorted members showing the most extreme grade of atrophy, and in which, later, we are expected to obtain satisfactory results by operative measures. A case of my series illustrates this well: R. E., a boy, first seen when three years old, had contracture of the sartorius, tensor vaginae femoris, and gluteus medius, so that the thigh was held flexed and abducted at right angles with the body. Operation was declined by the parents at the time, but

[1] Wright, Boston Med. and Surg. Jour., 1912, vol. clxvii, pages 567–574.

they returned for operation when he was 11 years old, and it was then found that there was a bone shortening of three inches. Normal epiphyseal stimulation had been lacking for some eight years.



FIG. 495.—Paralytic braces reinforced by leather and elastic straps to supplement weakened muscles. (*Young.*)

It is unquestionably true that braces and shoes for paralytics should be as light in weight and construction as is commensurate with durability. Before speaking of operative procedures I wish, therefore, to go on record as advocating the early use of braces, and in fact the use of braces in all cases in which the

lost balance of power or the effect of gravity may lead to distortion, with or without surgical intervention (Figs. 496 and 497).

c, Chronic stage. Despite efforts to lessen the result of the damage to the motor area in the cord, hundreds of patients seek surgical aid to overcome contractures, overactivity of certain muscles, and flail joints.

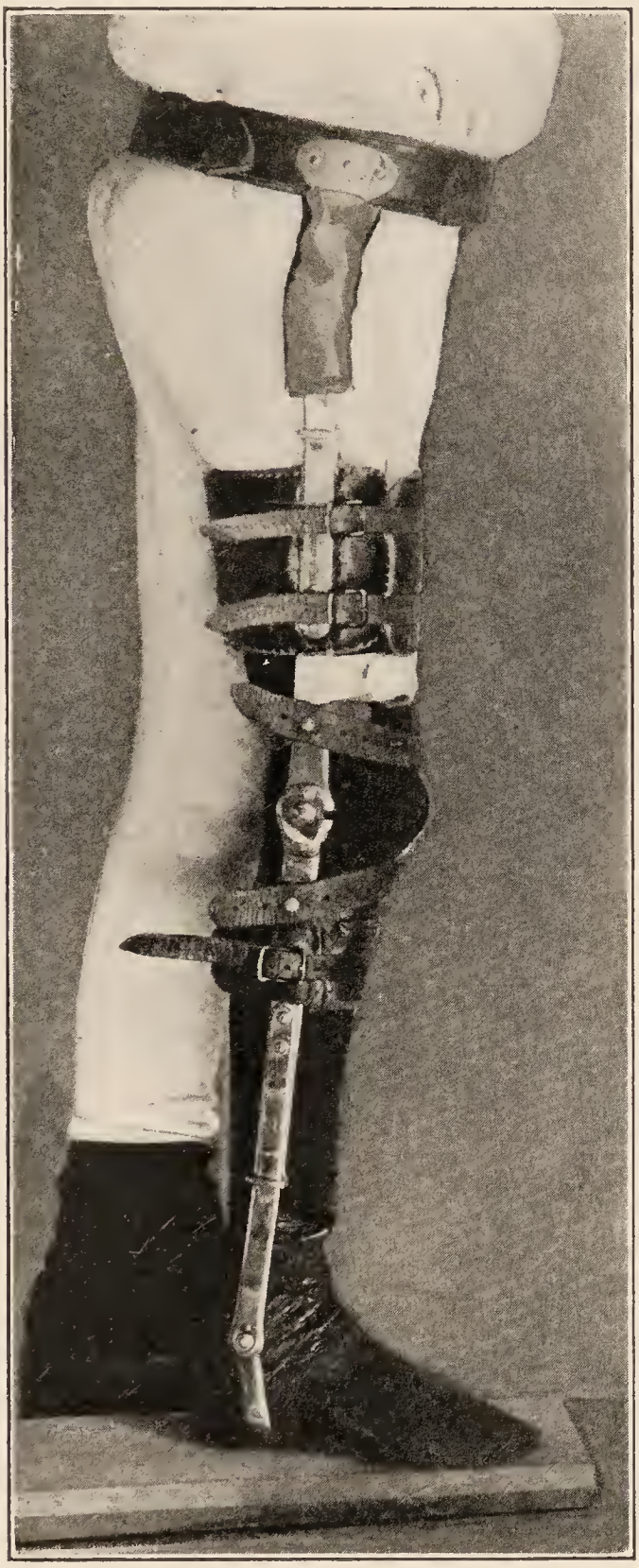


FIG. 496.—Paralytic braces with knee cap and pelvic band. (*Young.*)

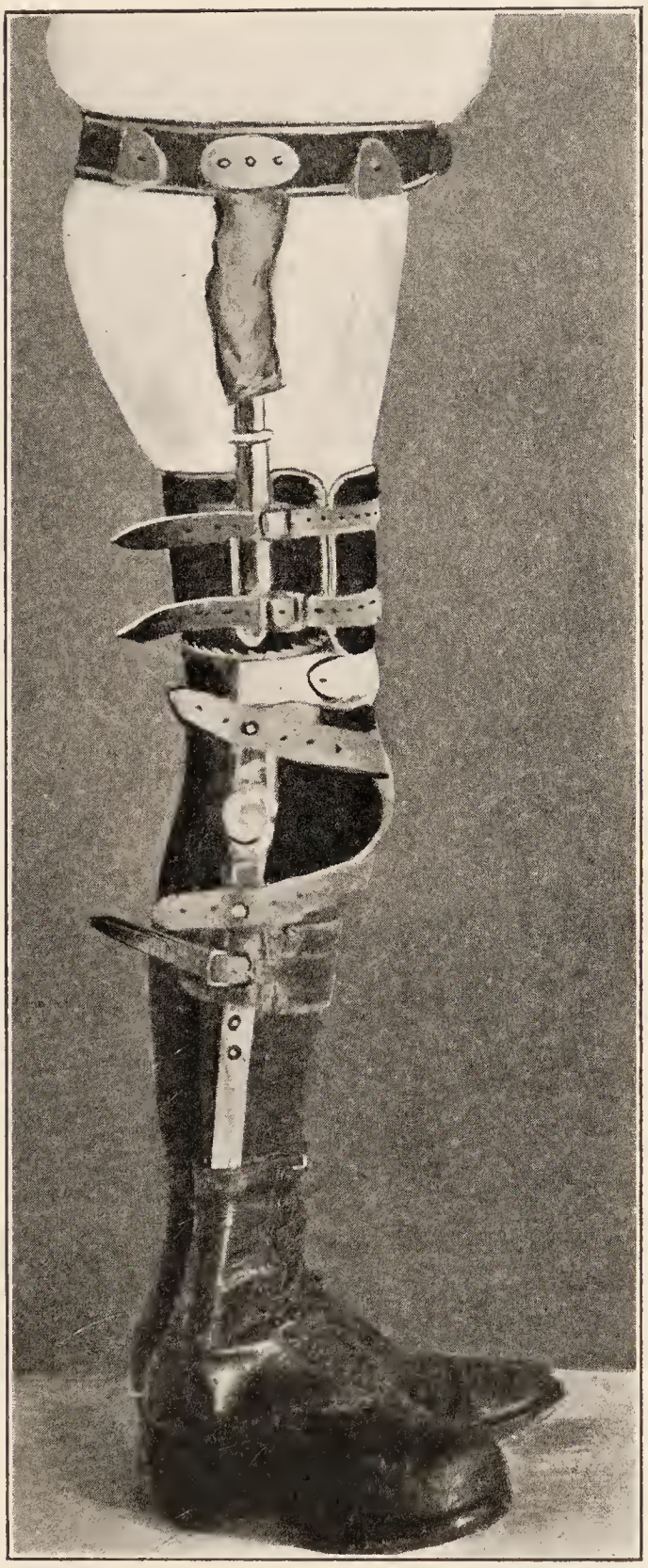


FIG. 497.—Paralytic braces and cork-soled shoe to equalize length of legs. (*Young.*)

The operative procedures of which we avail ourselves for the correction of the deformities and disabilities may be chiefly divided into:

1. Tenotomy.
2. Myotomy.
3. Tendon shortening.
4. Tendon lengthening.
5. Tenodesis.

6. Extra-articular silk ligaments.
7. Intra-articular silk ligaments.
8. Arthrodesis.
9. Articular transposition.
10. Astragalectomy, skeletal remodelling, and osteotomy.
11. Nerve anastomosis.
12. Tendon transplantation.

1 and 2. Of the first two named nothing need be said, as the procedures have been of such common performance since 1831, in the days of Delpech and Stromeyer, and orthopaedists daily now employ them, the world over, in correcting deformities by severing overactive muscles and lengthening them thereby; this overactivity is due to a paretic condition in the antagonist or antagonistic group as explained by Seligmuller's theories.

These operations are of distinct benefit, in that they not only restore the normal alignment in the members, but relieve the remaining weakened living muscular fibres in the paretic muscle from overstrain, which in itself is a detriment. As a rule, some mechanical device to prevent recontracture of the overstrong muscle is required in the after-treatment of all cases. Frequently tenotomy, myotomy, or even osteotomy is required as a preliminary operation to correct distortion some months prior to a secondary operation of tendon or muscle transference, the latter aiming chiefly to restore the balance of power and physiological function.

In April, 1891, Dr. De Forest Willard, Sr. reported and called attention to the great value of these procedures in a series of these cases before the Tenth International Congress at Berlin.

3. Tendon shortening by taking a tuck in it by suture, tying, or removal of a section has been done by various surgeons in the past. (See Chapter XXVI, Case 1.)

4. Tendon lengthening has been accomplished more often by tenotomy subcutaneously within the sheath, and lengthening has occurred by organization of the plastic exudate between the severed ends. Some few authorities prefer lengthening the tendon by oblique section and suture through an open incision. Again others prefer to lengthen by the Bayer Z or N section and then stretching. Again we find some instead of cutting the tendon transversely, cut it from below upward and forward through the width of the tendon to get a broader surface for sewing. (See Chapter IX, Fig. 57.)

5. Tenodesis was a procedure advocated by Hoffa and extensively used by him, of converting the tendons around a joint into ligaments by sewing them above and below a joint, to increase its stability when flail-like and to restore proper alignment and balance when distorted.

Gallie's[1] recently presented operation is akin to Hoffa's tenodesis in that he endeavors to secure more thorough joint fixation by using a whole or a part of a tendon near the ankle to produce a tendon fixation into the bone, which he has grooved with a gouge to sufficient depth to suture and bury the tendon and to cover it with the incised and elevated periosteum. He uses his method in

[1] Gallie, Annals of Surg., Jan. and Oct., 1915.

conjunction with tendon transplantation when overaction in one or more directions produces a disabling deformity, and also alone for flail joints. It promises to be a most useful procedure when tendon transplantation will not correct and produce an approximate restoration of function and balance. For paralytic talipes varus, Gallie recommends burying the tendon of the peroneus longus under tension on the anterior surface of the fibula and the peroneus brevis similarly on the posterior surface of that bone near the epiphysis, so that the varus position cannot be resumed. This procedure obviously however does not restore functional motion in abduction. In total paralysis of the triceps surae, he has the foot held in equinus and buries the tendo achillis in the posterior surface of the tibia and the peronei are transplanted peripherally into the os calcis. In partial paralysis of the triceps surae he splits the tendo achilles into an anterior and posterior half, passing the anterior half near its insertion in the os calcis through a slit in the anterior portion of its capsule and buries this in the tibia, while the foot is held overcorrected in the desired position.

In addition to Hoffa and Gallie, Tilanus,[1] of Amsterdam; Sangiorgi,[2] of Bologna; and Reiner,[3] of Vienna, have endeavored to do practically the same thing of making tendons into ligaments.

For our accurate methods in determining the relations of the foot to the leg and the anterior to the posterior portion of the foot, or what is normal functional weight-bearing, we have Whitman and Young, to thank for their thorough exposition in their textbooks on orthopaedic surgery. (See Chapter XXI, Figs. 406, 414 and 415.)

Young's method after Roberts of determining the angle of deflection is extremely useful to students and practitioners in understanding the degree of deformity in the lower extremities.

6. Extra-articular silk ligaments, chiefly to support a flail ankle, knee, or shoulder have been advocated by Lange and Allison.[4] The former has preferred silk ligaments to arthrodesis since 1903 and introduces from six to eight strong silk threads sutured to the periosteum of the scaphoid and tibia and cuboid and fibula, having passed through the adipose tissue from point to point. The upper point of attachment is five centimeters above the ankle joint.

Allison[5] uses the silk as a stirrup. With a drill having an eyelet which he threads, he passes the silk through the anterior tarsal bones from side to side of the foot, then threads a probe, which he passes under the annular ligament up to the crest of the tibia, where he makes an incision and sutures the two ends to the periosteum. Similarly, he threads the os calcis and passes the ends up for suture in the posterior aspect of the tibial periosteum for calcaneus, or both for flail ankle.

Lange[6] recommends fixation after the introduction of silik ligaments or tendons for one year and the use of braces for two years.

[1] Tilanus, Nad. Tijdschrift voor Genees Kunde, 1898, vol. ii, page 23.
[2] Sangiorgi, Revista de Ortopedia, 1901, page 1.
[3] Reiner, Zeitsch. f. Ortho. Chir., 1903, page 2.
[4] Lange, Amer. Jour. Ortho. Surg., vol. viii, page 8.
[5] Allison, Amer. Jour. Orth. Surg., 1913, page 519.
[6] Lange, Munch. med. Woch., 1907, page 17.

7. Bartow and Plummer[1] describe artificial ligaments of silk which are both intra-osseous and intra-articular, passed into and through joints in the desired direction to restrict or limit motion, to be used exclusively in flail joints. It is especially adapted for use at the knee, ankle, and shoulder, using 14–20 Corticelli silk. Allied somewhat, only so far as the effect obtained is concerned, is the operation of Robert Jones[2] for flail elbow, where we have a useful hand which is valueless when the arm hangs at the side. He removes a diamond shaped flap of skin from the front of the elbow, of sufficient size so that the two equal triangles which go to make up the diamond when approximated and sutured, will hold the forearm at 140° flexion with the arm, the most useful angle.

8. Arthrodesis for flail joints was described at length by Townsend[3] and Goldthwait[4] in excellent articles which will be found in the Transactions of the American Orthopaedic Association. This procedure especially for the ankle, has many warm advocates, as it enables the paralytic in many cases to do without a brace. It is valuable at the shoulder in deltoid paralysis. A bone peg driven through the acromion into the humeral head after removal of synovial membrane and cartilage has recently been advised by Straub.[5] At the hip and knee, arthrodesis is rarely done and never at the hip, knee, and ankle of the same subject. Augustus Wilson[6] strongly advocated this procedure.

Gill and Davis advocated stiffening of the ankle in slight "foot-drop" to give a "back-knee" in quadriceps and anterior tibial paralysis to do away with braces.

Lange, objects to what may be called mutilating operations, that is abolishing a function, but agrees that at times, to give a patient the ability to walk, such a procedure is justified. He prefers the extra-articular silk ligaments to arthrodesis, however, because the stiff ankled patient is handicapped on rough ground and is fatigued more easily despite the fact that he walks better on a level floor.

Townsend puts the minimum age when this operation should be done at six or eight and Lange at 14 years on account of the cartilaginous nature of the joint and difficulty in obtaining true osseous union.

9. Gwilym Davis had devised, but, so far as I am aware, had not published an ingenious and efficient operation for paralytic talipes calcaneus in which he makes a transverse horizontal section through the os calcis just below the articular surface adjacent to the astragalus. He then slides the heel back and the tibia, fibula, and astragalus forward, so that the weight falls upon the anterior portion of the os calcis, and calcaneous is impossible. This procedure I have classified as "articular transposition." His results are excellent.

10. Whitman[7] has been the author and chief advocate of astragalectomy for talipes calcaneus (Fig. 430).

[1] Bartow and Plummer, Ibidem, May, 1913; New York Med. Jour., May 3, 1913; N. Y. State Jour. of Med., Sept., 1915.

[2] Robert Jones, Trans. Amer. Ortho. Assoc., vol. xv, page 93.

[3] Townsend, Ibidem.

[4] Goldthwait, Ibidem.

[5] Straub, Surg., Gyn. and Obst., Apr., 1922.

[6] Wilson, Amer. Med., Apr. 8, 1905.

[7] Whitman, Amer. Jour. Ortho. Surg., vol. viii, page 137.

After removal he slides the tibia and fibula forward, and the recurrence of calcaneus is practically prevented as in Davis's operation. The mutilation, prevention of other motions, and shortening of the limb are its chief objections, but the gait secured is excellent and the deformity is corrected.

Skeletal remodeling of the tarsus has been advocated by Hoke,[1] so that the bones are so shaped by curretting, that the foot can be moulded to bear the weight upon any given part, thus correcting many static deformities. Many of us do the same thing after other procedures, provided that we find the bones so distorted that by fixation an unreasonable time would be required for a physiological bone transformation, according to Wolff's law, to take place. Such a contingency is rare in paralytic deformities. Other writers have advocated osteotomy of the neck of the astragalus for paralytic valgus and varus deformities and osteotomy of the posterior portion of the os calcis for calcaneus.

11. New hope was raised by Spitzy,[2] of Gratz, Austria, when he presented his paper in 1904, on nerve anastomosis for the cure of Infantile Paralysis. This procedure had been successful in secondary suture after traumatic section of nerves, and in facial paralysis. Spitzy was successful experimentally in dog's legs, in anastomosing nerves both centrally and peripherally, and Howell[3] anastomosed flexor nerves into extensor and vice versa in dogs' legs, but neuroplasty has failed to meet expectations in anterior poliomyelitis, when the peripheral end of a paralyzed nerve was sutured into a functioning nerve or a slip from a functioning nerve was attached to a paralyzed nerve.

There is evidently a general impairment in all the nerves, in a partially paralyzed extremity, and a nerve anastomosis is like taxing an already weak and run down battery with more work. The writer has reported results and bibliography of neuroplasty in a paper.[4] Recently, experimental work on animals, with a few clinical cases, have been reported upon what is called the "neurotization" of muscles, by Erlacher,[5] Steindler,[6] Heineke,[7] and others, whereby (*a*) functioning motor nerves are sewed directly into paralyzed muscles, (*b*) underactive muscles are supplied with additional motor nerve from a relatively overactive source and "hyperneurotization" is produced (*c*), intermuscular septa or sheaths are removed between paralyzed and nonparalyzed muscles, and the two sutured together, resulting in new nerve fibres and end plates forming in the dead from the living ("muscular neurotization"), and (*d*), flaps from a living muscle are sewed into a paralyzed muscle with the same result. Improvement is reported in a few weeks, but sufficient time and more cases are needed to determine the real worth of these procedures.

12. We now come to the most important and useful surgical procedure for the relief of infantile paralysis, namely, tendon transplantation.

[1] Hoke, Southern Med. Jour., 1915.
[2] Spitzy, Trans. Amer. Ortho. Assoc., vol. xvii, page 14.
[3] Howell, Jour. of Phys. (Cambridge), vol. xiii, No. 5, page 335, and vol. xiv, No. 1, page 1.
[4] Taylor, N. Y. Med. Jour., July 7, 1906.
[5] Erlacher, Amer. Jour. Ortho. Surg., July, 1915, vol. xiii, No. 1, page 22.
[6] Steindler, Ibidem, page 33.
[7] Heineke, Zentralbl. f. Chir., 1914, vol. xli; Archiv f. Klin. Chir., 1914, vol. cv.

Tendon Transplantation on Tendon.

Tendon transplantation or transference, first popularized in 1880 by Nicoladoni abroad, and in this country by Goldthwait,[1] in 1895, gave us hope that the attachment of the distal tendon of the weakened muscle to one still alive and functionally active, would help restore support and use to the paralyzed tendon, but only in rare instances have these cases yielded results which enabled the patient to do without artificial support. Dane's statistics of 50 cases from the Children's Hospital, Boston, were discouraging, as were reports from elsewhere in this country and abroad.

Tendon Transplantation to Periosteum.

Since 1899, by means of the new method of Lange, as it is called, in contradistinction to the older method of Nicoladoni, we suture the tendon to the periosteum or a silk prolongation of the tendon to the periosteum, or actually pass the tendon through a bony canal, or sew it to the bone, or reduplicate it on and suture it by Ryerson's method[2] to itself. This seems to have maintained the desired muscular tension much better and to have accomplished the aim we have in view more satisfactorily in the writer's hands, and, as reported by Hoffa, Augustus Wilson, Dane, LeBreton, and others. Lange's[3] method of elongating short tendons by means of silk sutures—preferably white sublimated—coated with paraffin, and giving these a periosteal attachment, has also yielded some results in my experience. Auger first used silk to lengthen tendons in 1875, to which Lange calls our attention, but Lange popularized its use. Distinctly disappointing to the writer, however, have been the results of the operation for the relief of paralytic flat-foot in cases in which the tibialis anticus and posticus are paralyzed and the extensor longus hallucis has retained its vitality and tonicity, where this muscle is used. Advocated by Mutel and others through a tunnel, transplantation has been made through the scaphoid, internal cuneiform, or first metatarsal.

In these cases infinitely better results are to be obtained as we should naturally expect from a logical, mechanical study of the problem, by taking either the peroneus longus or brevis tendon, preferably the former, and suturing it into the scaphoid, for thereby we create a balance of power from the active tonicity of the two peronei, one on the outer side on the foot and one of the inner side, whereas, with extensor hallucis transplantation, one small muscle is pulling against the two strong peronei muscles and failure results.

In the operation of using the extensor longus hallucis we shall almost invariably find that it is, even though it possesses normal contractility, unequal to the task of holding up the arch and restoring the normal adduction of the foot when opposed to the combined overactivity of the two peronei. It is needless to say how ridiculous—mechanically and anatomically—it is to take slips from the tendo achillis for the correction of valgus or varus, as advanced by some tyros. Equally foolish is it to take slips from any muscle or expect one part to perform one function and another a different function.

[1] Goldthwait, Ibidem, vol. viii, page 20.

[2] Ryerson, Jour. A. M. A., vol. lxi, page 18.

[3] Lange, Jour. Amer. Ortho. Assoc., vol. viii, page 15.

By all surgeons who have done a large amount of tendon transplantation the one great essential to be borne in mind—as pointed out by Schantz—is that the transplanted tendon and muscle must pull in a straight line and not around a corner, so to speak, from origin to insertion, in order to get the best mechanical and functional results. We cannot agree with Lange that only the lower third or half need pull in a straight line; thus he acknowledges he cannot make a peroneus muscle into an adductor and we can, by improved mechanics and technique.

Importance of the Annular Ligaments.—An additional point of value the writer wishes to call to the attention in this work on the extremities, is the utilization of the annular ligament at the ankle. If the muscle and tendon is trans-

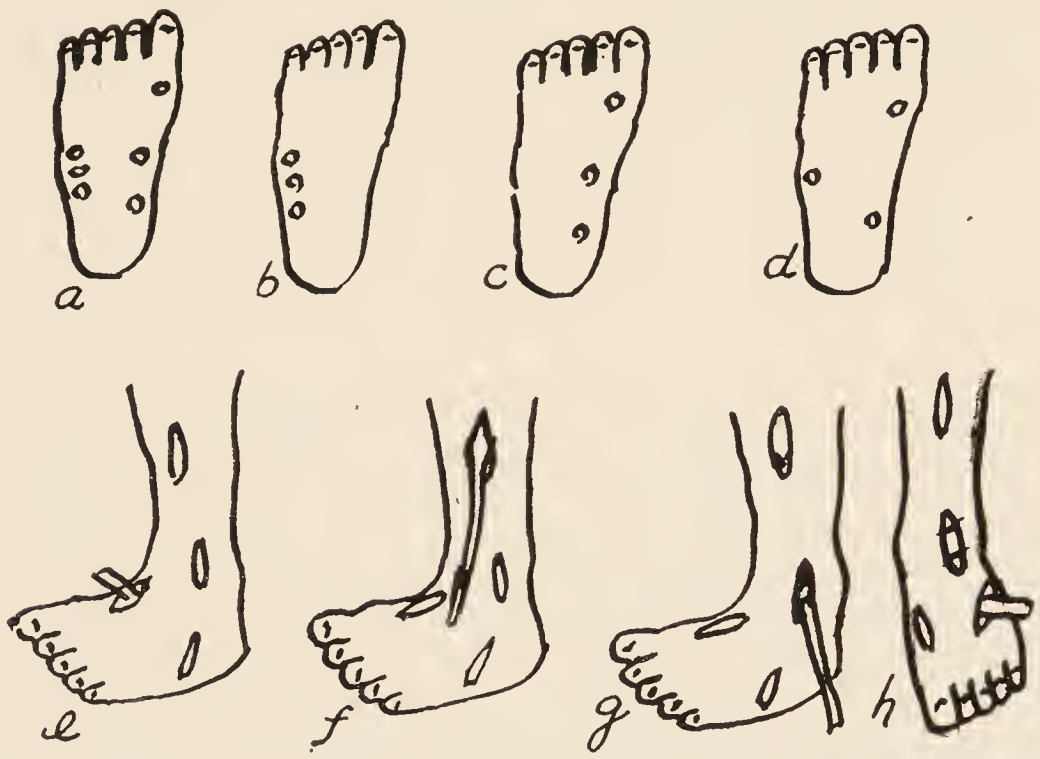


FIG. 498.—*a*, Shows diagrammatically the efficient points of traction of the tendons in the normal foot. *b*, In paralysis of the tibialis anticus and posticus and extensor longus hallucis, the unopposed action of the intact peronei pull the foot into valgus. *c*, In paralysis of the peronei the reverse takes place and the inner muscles pull the foot into varus or club foot. *d*, Shows a restoration of balance in paralytic club foot by the transplantation of the tibialis anticus to the outer side of the foot to take the place of the paralyzed peronei. *e*, Shows the four incisions in the Author's method of correcting paralytic club foot and the freeing of the tibialis anticus. *f*, pulled out of its sheath through incision 2; *g*, the tendon of the tibialis anticus passed through the subcutaneous fat and under the annular ligament of the outer anterior aspect of the ankle; *h*, the incision over the base of the fifth metatarsal bone where the tibialis tendon is to be sutured.

ferred from the origin to the new insertion through the subcutaneous fat, the normal tension can by no means be maintained, and furthermore, there is an unsightly ridge under the skin, whereas both of these objections are obviated by passing the tendon under one of the thecal compartments of the annular ligament in line with the new and desired direction of traction. Rugh[1] has drawn attention to the important "snatch block" function of the annular ligament in preventing flat-foot.

The Writer's Operation.

The following operations have been constantly employed by the writer since 1909 and in some 1000 cases of leg and foot paralysis, having been first reported before the Washington County Medical Society at Hagerstown, Md., November 10, 1910[2] (Figs. 498 and 499).

[1] Rugh, Ibidem, page 495.

[2] Taylor, Amer. Jour. of Surg., Nov., 1911.

After the circulation has been cut off by the Esmarch bloodless bandage and tourniquet in the usual manner, four small incisions are made as follows: First, at the insertion of the overactive muscle, which is severed as low down as possible; second, over that portion of the same muscle where the muscular fibres first become tendinous; through this wound the freed tendon is withdrawn and the

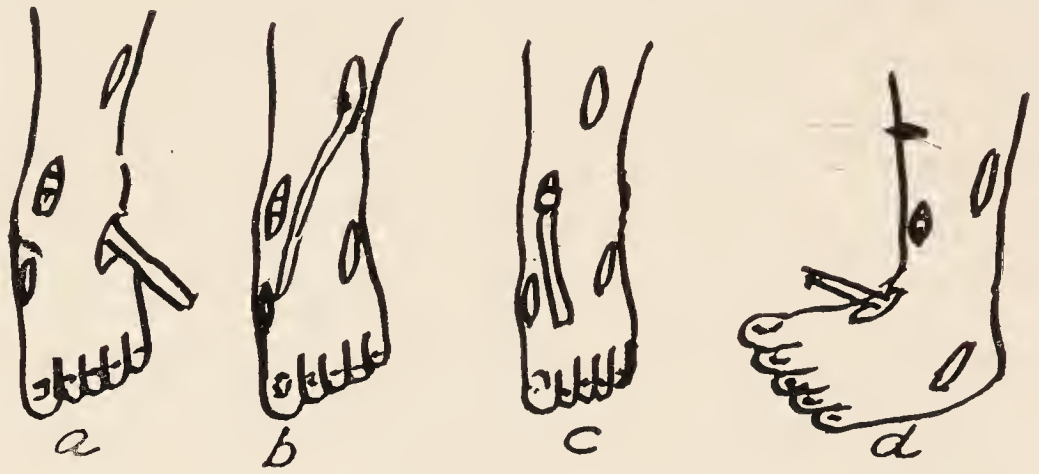


FIG. 499.—*a*, Incisions for paralytic flat foot or valgus and the tendon of the peroneus longus cut free; *b*, incision over musculo-tendinous portion of peroneus longus and the tendon pulled out of the sheath; *c*, the tendon passed under the annular ligament on the antero-internal aspect of the ankle; *d*, the incision at the base of the first metatarsal where the peroneus longus tendon is to be inserted and sutured.

whole covered with a wet, normal salt solution sponge to prevent drying the tissues; third, over the annular ligament; and fourth, at the proposed insertion down through the periosteum (Figs. 54, 55, 500, 501, 502 and 503).

Curved hysterectomy forceps or a hemostat is passed from the annular ligament wound, through the subcutaneous fat, to the belly of the muscle, where



FIG. 500.—Left paralytic flat foot.

the freed distal end of the tendon is passed and this is drawn down to the annular ligament. A very small hemostat or mosquito forceps or probe, after the exact direction desired is determined, is passed under the annular ligament through an appropriate compartment and the end grasped and drawn through. If the tendon will not reach to the desired insertion, which is rare, one or more strands

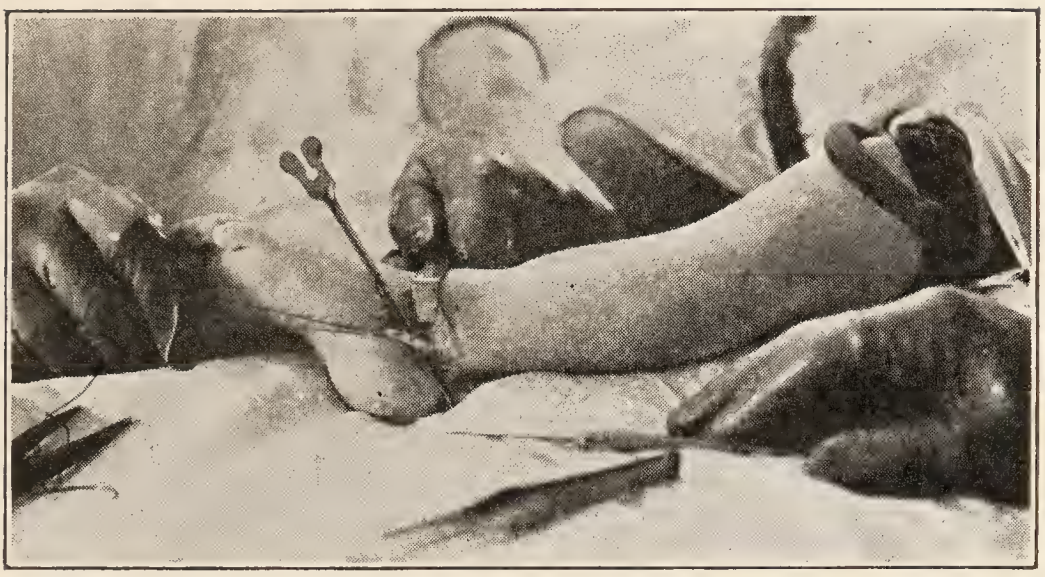


FIG. 501.—The same, showing the Peroneus Longus exposed and a black silk stay suture put in to secure control and avoid handling of tendon itself. Also to be used in case of need as suggested by Lange for extension of tendon should it prove too short.

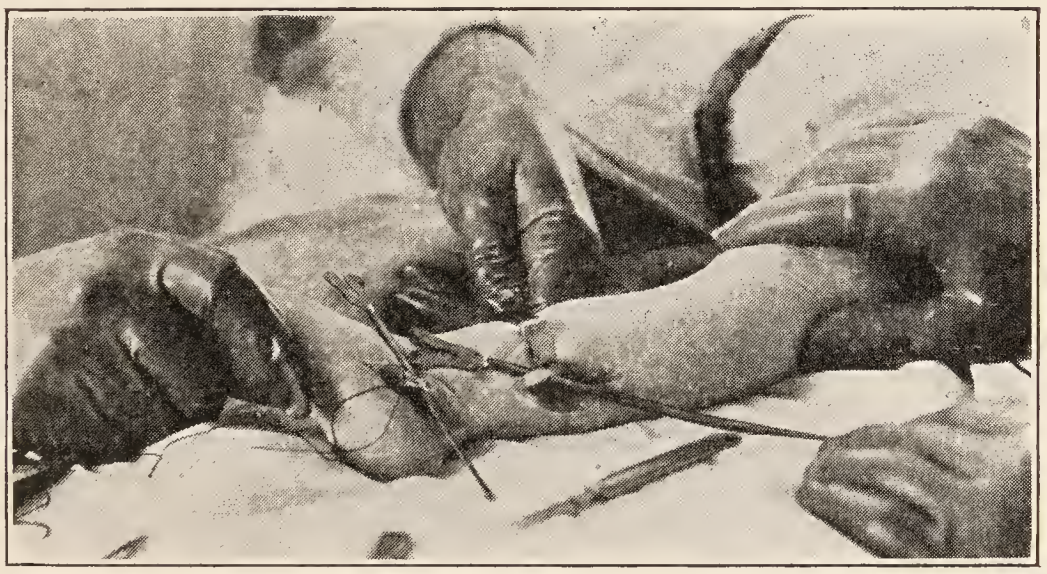


FIG. 502.—Exposure of the musculotendinous portion of peroneus longus.



FIG. 503.—The tendon of the peroneus longus cut as low down as possible and pulled out of sheath.

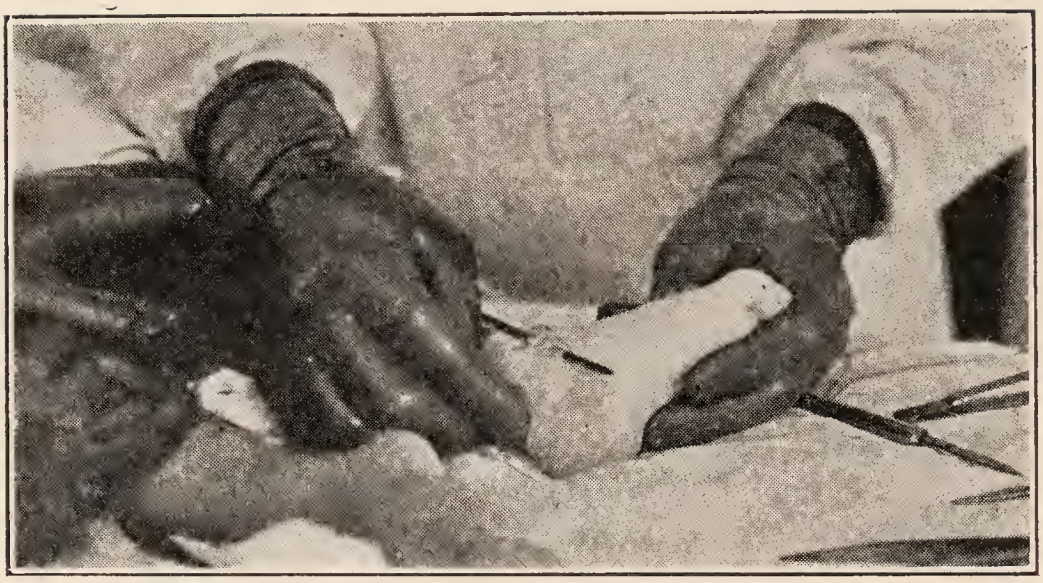


FIG. 504.—Annular ligament exposed on antero-internal aspect of ankle.

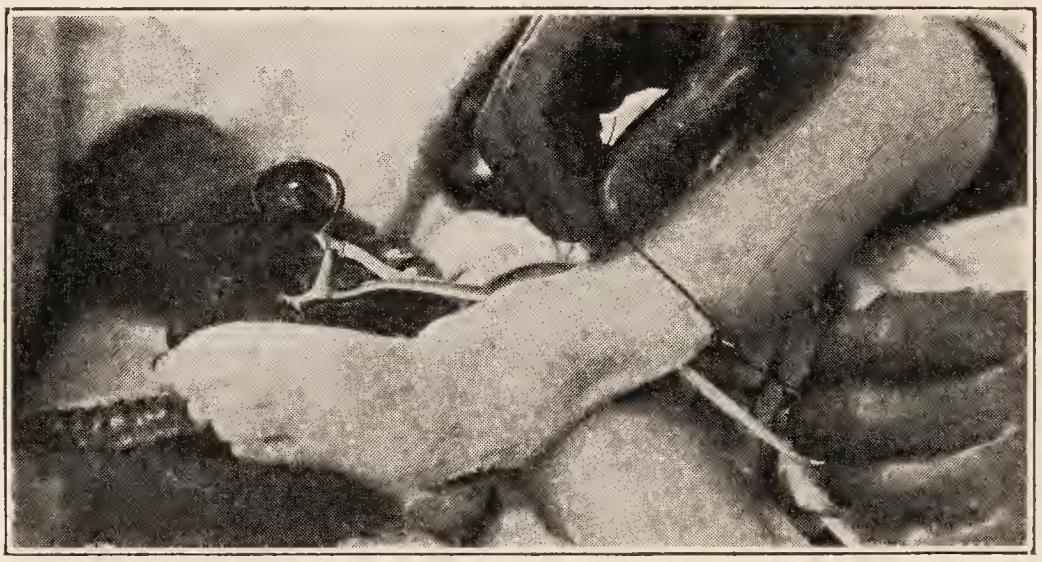


FIG. 505.—Kelly haemostat passed through fat to second incision to grasp stay suture in distal end of freed tendon.



FIG. 506.—The stay-suture and tendon pulled through to top of annular ligament.



FIG. 507.—The tendon pulled under annular ligament by mosquito forceps shown in Fig. 506.

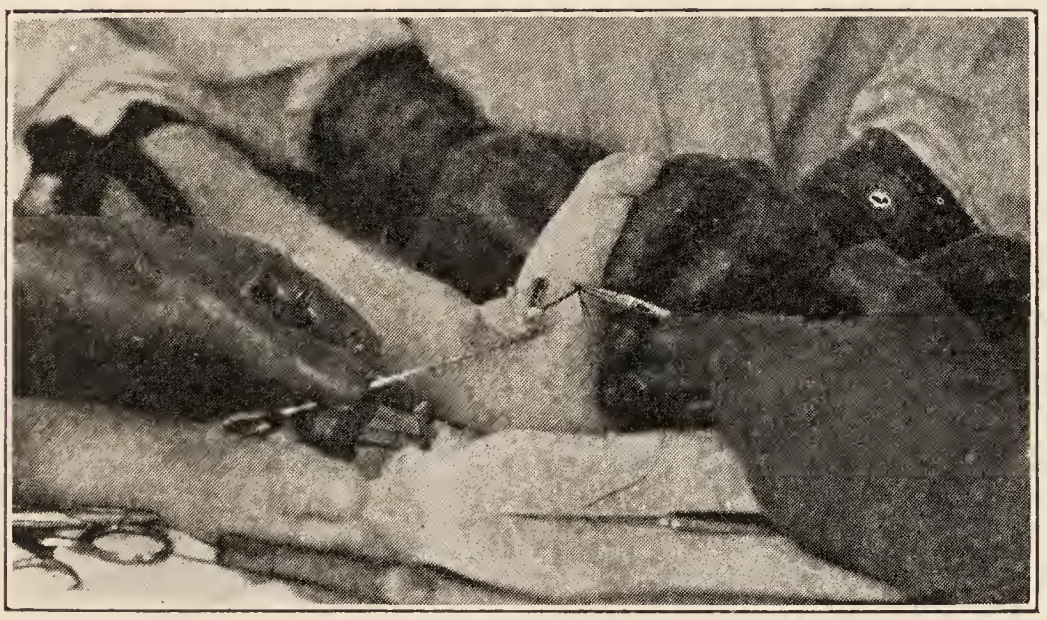


FIG. 508.—After subcutaneous tenotomy of the tendo achillis and an incision over the base of the metatarsal bone of the great toe from which a strip of bone is removed (shown on the child's instep) the tendon is pulled by forceps through the subcutaneous fat.

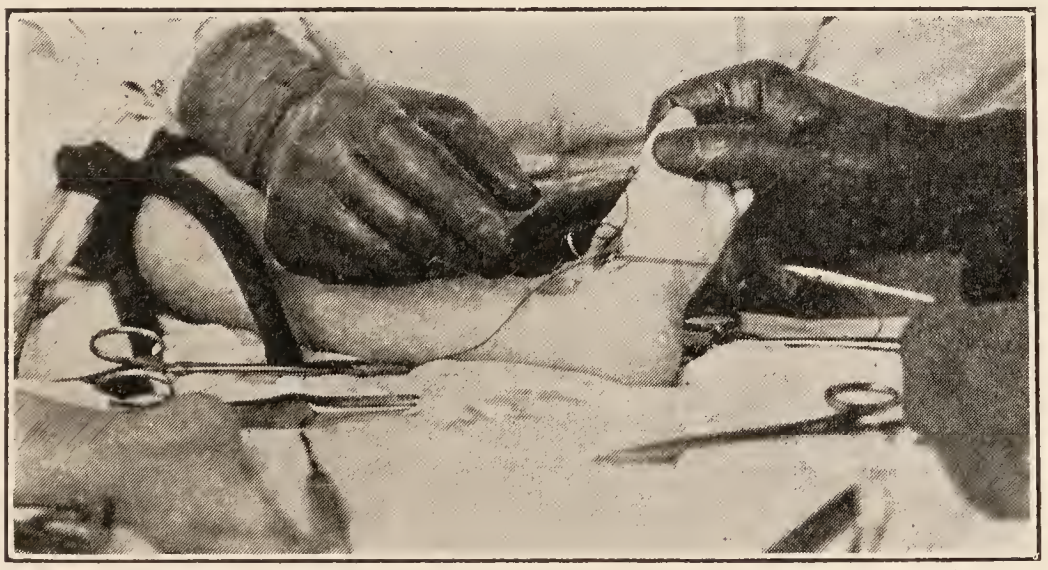


FIG. 509.—It is sutured to the bone and periosteum, while tension is made on the stay suture and the foot is held in an overcorrected position. Photographs are of an actual operation, not cadaver.

of black braided silk are quilted into the tendon and it is pulled from the bottom of the annular ligament subcutaneously to the desired point of insertion, where it is firmly sewed to the periosteum, or preferably into a notch in the bone. Lange first pointed out that silk strands offered a framework for the tendinous tissue to grow about and between. If the transferred tendon is long enough, it may be sewed directly to the periosteum and bone and it usually is. For the past ten years I have cut out a groove in the bone at the point of insertion. The deformity must be thoroughly overcorrected and the tendon sutured under tension (Figs. 504 to 509).



FIG. 510.—Gun-shot destruction of phalanges and greater portion of fifth metatarsal as well as the peroneus longus and brevis tendons. Painful scar, spur of fifth metatarsal and overaction of tibials anticus causes weight bearing (extreme supination) to fall on outer border of foot.



FIG. 511.—The same.

Withdrawing the tendon from its sheath, i.e., from incision 1 to incision 2, and ultimately disregarding the old sheath, *does not appear to affect the nutrition nor ultimate function of the transferred tendon in the slightest degree.* It is possible to imagine a new sheath is regenerated from the subcutaneous and adipose tissues. Mayer and others think a plastic sheath should be made or the original sheath transplanted, if possible (Figs. 510, 511, 512 and 513).

I have used repeatedly Lange's heavy braided white silk imbedded in paraffin, after boiling in 1 to 5000 bichloride solution, but find in practice that the

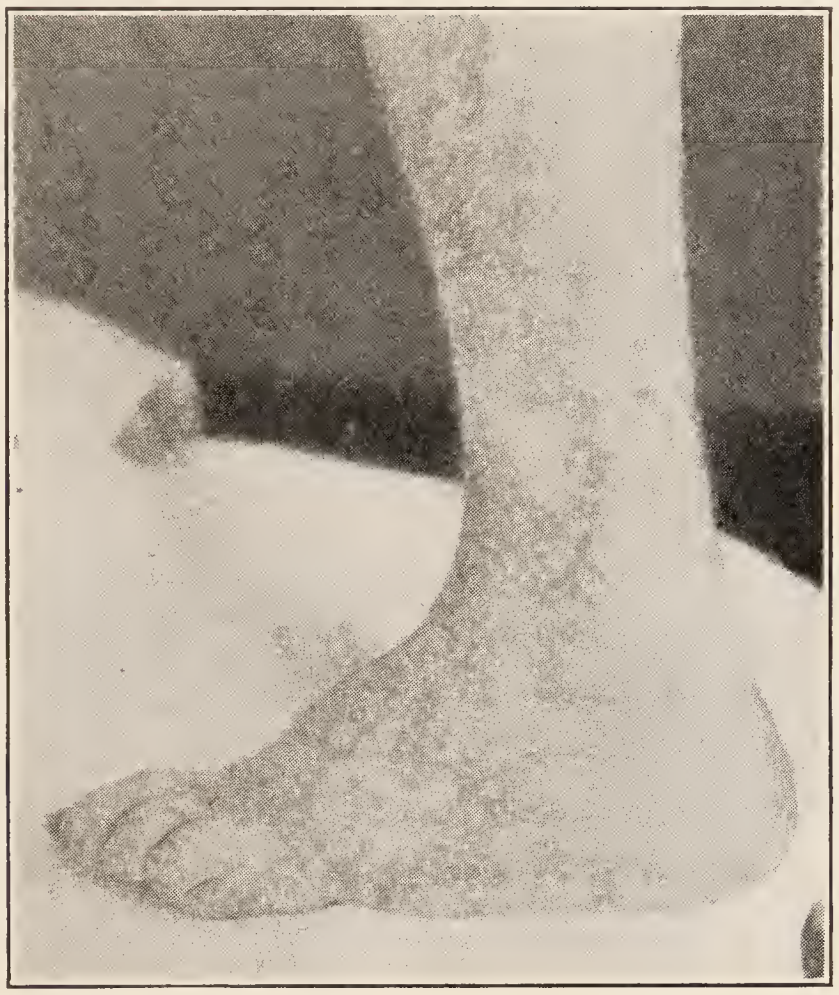


FIG. 512.—The same.



FIG. 513.—After transplantation of tibialis anticus and removal of bone spur painless weight bearing on inner border of foot and good function is evident. Note transplanted tendon functioning.

ordinary black No. 5 braided silk, or even preferably fine intestinal silk, boiled five minutes in a sterilizer, is all that is necessary. The wounds are closed

tightly with the subcuticular continuous chromic catgut No. 2 and then covered with silver foil, the usual dressing, and plaster cast. The cast is continued for eight weeks. For a month the patient must bear no weight on the cast, and then for a month a sandal is worn over the cast for walking. At the end of this period, bracing or supports are often not required.

Gallie has recently advocated suture of tendon to periosteum with strips of fascia lata.

No tendon transference or similar operation should be done for at least two years after the paralysis occurs.

It is needless to say that the foot or part is put up in over-correction to overcome the deformity and secure tension of the transplanted tendon. Massage, passive and then active, then resistive movements, together with slowly interrupted Faradic stimulation, form important adjuncts to the after-treatment of these cases.

Conclusion.

In conclusion, the following points should be emphasized. We should be more careful in the early recognition of infantile paralysis and use appropriate means to prevent its spread.

Elimination of the toxin should be facilitated in every possible way. As hexamethylenamine has apparently helped some and can do no harm, it should be employed in the earlier stages. Early lumbar puncture and the use of immune serum should be used with intraspinal dosage of adrenalin chloride. Rest is most important in order to give the muscles a chance and freedom from strain. Warmth helps the hyperesthesia and nerve pain. No matter whether a part is apparently paralyzed or not, efforts at assisted active moments should be tried and passive movements and massage given, possibly aided by Faradic electricity, slowly interrupted by a pendulum to produce muscular contractures, no matter how slight. Braces must be used, as light as possible, to compensate for muscular deficiency, prevent contractures, and promote normal physiological balance and alignment.

In regard to operative procedures, tenotomy and myotomy must be employed later when moderate stretching will not affect the desired lengthening of overactive muscles. Tendon transplantation may be resorted to two years after the attack, based upon careful scientific and mechanical study to produce a proper distribution and balance of power and support. Some form of tenodesis by tendon or silk can be used to supplement the tendon transplantation, if the alignment is not perfect and relaxation of a joint exists. Arthrodesis is the operation of choice at the shoulder and often at the ankle, in flail joints.

As in the writer's method, the tendon must be carried straight from the origin to the new insertion to gain the greatest mechanical efficiency, and the annular ligament must be employed when possible to take up any slack in the new order of things. The tendon is more securely fixed if sutured to a notch in the bone, retained in a fixed dressing for two months, and without weight-bearing for one month.

Mutilating operations should be avoided as far as possible and used en dernier ressort.

CHAPTER XXIII

THE SPASTIC PARALYSES OF CHILDHOOD

These forms of palsy, often spoken of as Birth Palsy, form a group second only in importance to the flaccid paralyses that we see in children as a result of Infantile Paralysis. They are easily recognized more often dating from birth and characterized by extreme rigidity and distortion of the limbs. Associated with deformities in the extremities, sometimes a Torticollis is seen, which may

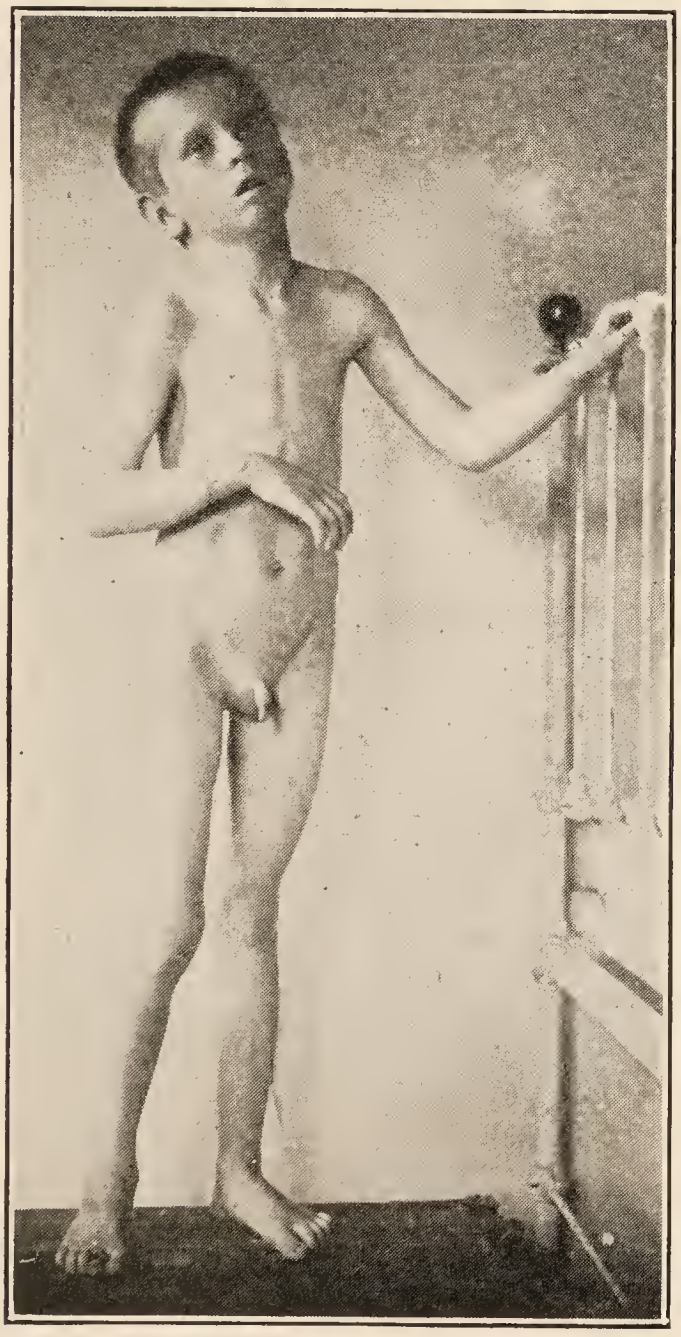


FIG. 514.—Right cerebral hemiplegia.



FIG. 515.—Cerebral diplegia.

be spasmodic. Deviations of the spine are less common as a result of these affections than in Anterior Poliomyelitis. From the time of Reil in 1812, down to Osler in 1888, valuable papers appeared on this disease and Osler gives a complete bibliography up to the time of his article.[1] Valuable surgical papers may be found in the Orthopaedic Journals. Probably the most outstanding article that appeared early upon this disease was by Little in 1853 and hence this disease is often spoken of as "Little's Disease."

[1] Med. News, July 14, to Aug. 11, 1888.

Usually there may be classified two main divisions in the distribution of the effects of this paralysis, depending upon whether one side, called a Unilateral Paralysis or a Hemiplegia exists, or both sides known as a Bilateral Paralysis or a Paraplegia is present. If only one extremity is involved, it is spoken of as a Monoplegia and if a double Hemiplegia is present, involving all four extremities, it is called a Diplegia (Figs. 514 and 515).

Frequency.

Only a small percentage of the Hemiplegic are congenital, whereas the Paraplegic and Diplegic nearly always date from birth, with a small proportion of the leg paralyses alone occurring as a result of disease or sickness in the first few years of life. The disease is equally frequent in boys and girls.

Etiology.

Any condition producing changes in the motor cortex of the brain where hemorrhage with cicatrization and pressure traumatism from without or metastatic meningitis as a sequila to systemic disease may be factors in the etiology. A small percentage, usually hopelessly idiotic, are congenital and some of these are due to Agenesis Corticalis or the partial non-development of the motor areas in the brain. Among the infections diseases that may cause spastic conditions may be named Cerebro-Spinal Meningitis, Scarlet Fever, Diphtheria, Typhus, Small Pox, Whooping Cough, Mumps and Dysentery, of which the cerebral symptoms are sequilae. Instrumental delivery or abnormal labor, premature birth, more often in the seventh month, convulsions and violent vomiting, Syphilis, thrombosis of the superficial cerebral veins, rupture of the longitudinal sinus, drunkenness at the time of conception and the marriage of close relations seem in the histories to bear a relation of cause and effect. But little credence is now placed in maternal impressions. Strong emotions and fright do not seem to necessarily produce these brain defects unless accompanied by a fall of the mother or injury to the developing foetus. In one recent case of the writer's, a seven month premature birth, the mother attributed the cause to an attack of a horse, loose in a field, across which she had to go. Naturally she was very much terrified when the horse charged on her endeavoring to both bite and kick her, both of which she fortunately escaped, but fell on the ground, fainted and was confined within a week of this unfortunate experience. Frequently one gets a history of still birth and alternate plunging in hot and cold water or rough artificial respiration before breathing is established, as a stated cause laid at the door of the accoucheur by the parents.

Hemiplegia.

Symptoms.—After birth, usually during the first three years of life, accompanied by some fever or following one of the Acute Exanthemata or some injury, the infant has a convulsion or series of convulsions. This is followed by a loss of consciousness, which upon recovery leaves the patient with paralysis of one side. The face and speech are less often involved in these cortical paralyses in children than is the case in the medullary apoplexy of advanced age from atheromatous endarteritis and arterio-sclerosis. The arm is more seriously

involved than the leg and partial or complete recovery of the leg may take place. The rigid distortions or deformities usually seen in the arm are a flexed elbow with adduction of the arm, semi-pronation of the forearm, wrist drop, adducted thumb, flexion of the first phalanges and extension or flexion of the terminal phalanges. Any voluntary effort in these children, when older, to straighten out these same positions are usually accompanied by an exaggeration of the spasticity. Some atrophy is always present, in the affected arm to a greater degree than in the leg, but not nearly so pronounced as that seen in

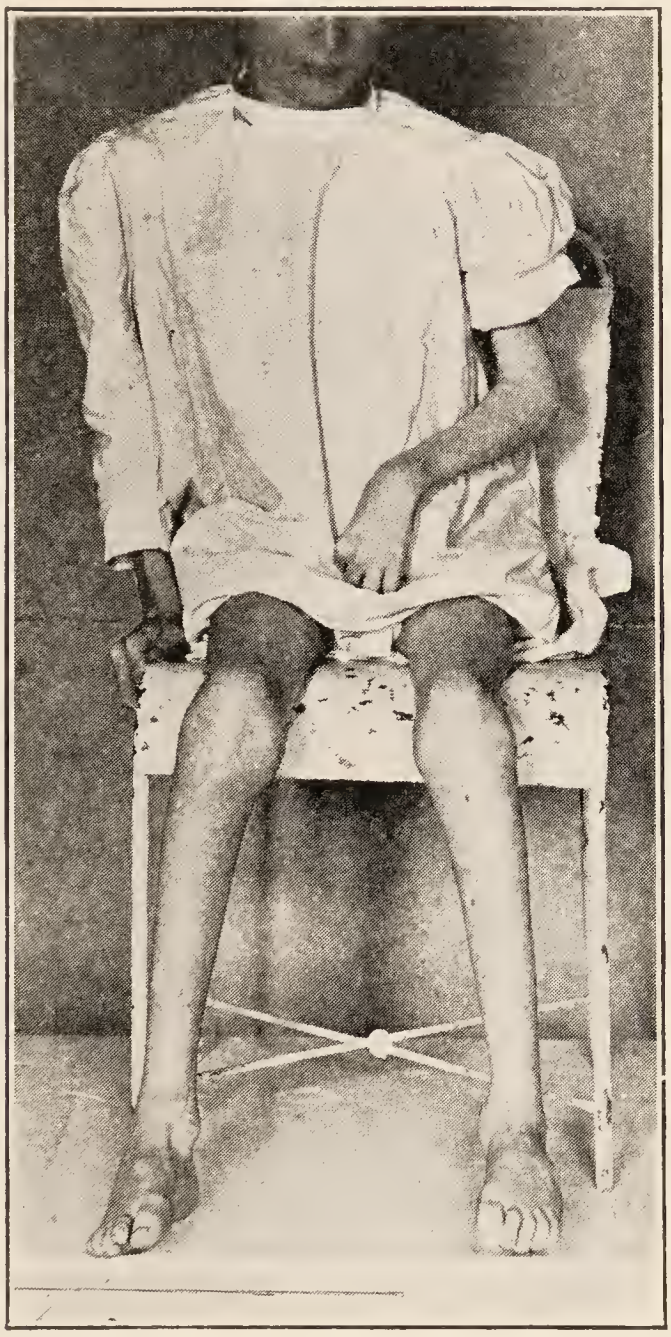


FIG. 516.—Monoplegia of left arm.

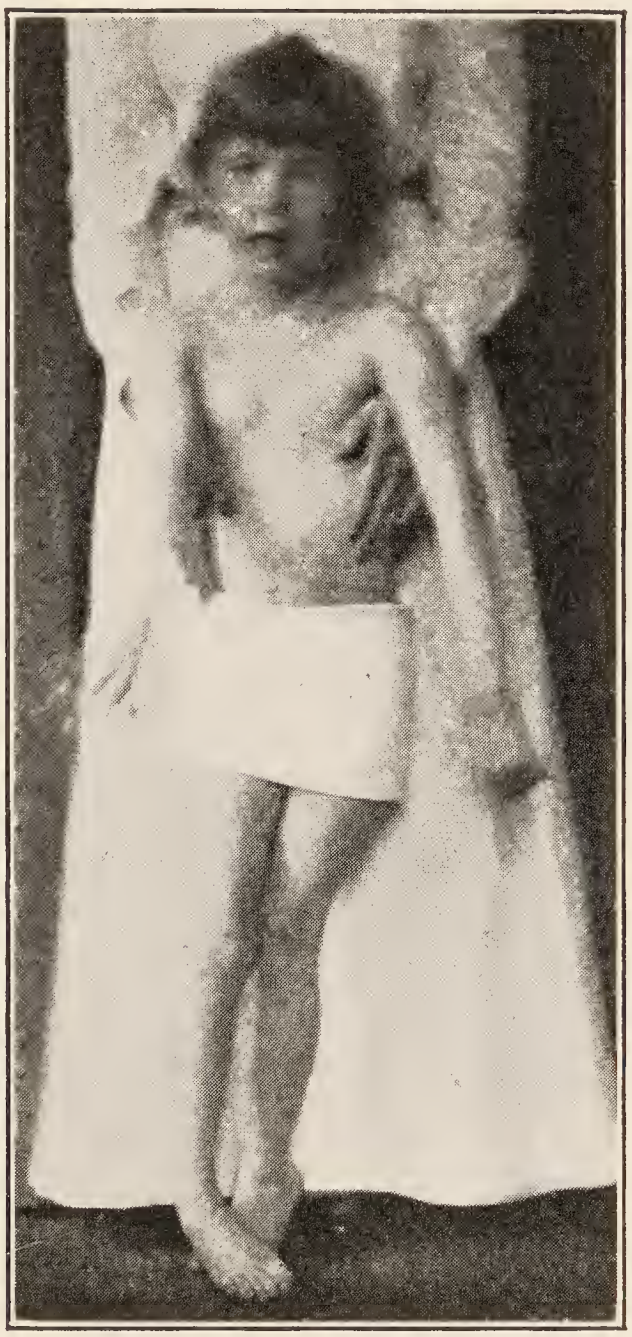


FIG. 517.—Congenital diplegia. "Scissors gait."

Acute Poliomyelitis. The distortions of the leg are usually flexion of the knee and extension of the foot in equinus or equino-varus. The thigh is flexed and adducted. The reflexes are exaggerated in nearly all cases. There is not the coldness of the skin nor pallor seen in Infantile Paralysis. Jacksonian Epilepsy is present in 25 per cent. of these cases of Hemiplegia. In perhaps 10 per cent. of the cases we encounter a tremor or constant movement, which is spoken of as Athetosis or Post-paralytic Chorea or Chorea Spastica. Nearly all of these children are more or less backward mentally, which may be only slight or amount to imbecility or even idiocy. The reflexes in practically all of these cases are increased and if started persist for some minutes, which also renders them diametrically opposite to Infantile Paralysis with its loss of reflexes.

The electric reactions are unaltered and all movements are characterized by an extreme incoördination or awkwardness. The muscles of the eyes are frequently involved, so that we have forms of internal strabismus, external strabismus and occasionally nystagmus (Fig. 516).

Spastic Diplegia.

This is simply a double form of the Hemiplegia and the same manifestation of a serious cortical injury. The mental defects and all symptoms are more



FIG. 518.—The same, side view of efforts to stand and walk.



FIG. 519.—The same after myotomies and tenotomies in double plaster of paris spicas with interposed stick.

severe, as a rule. The child may drool and saliva may be seen running from the mouth. In some instances, however, we see children with this variety with fair mentality (Figs. 517, 518 and 519).

Paraplegia.

Perhaps the most striking feature in Paraplegia is in the crossed legs, from spasm of the adductors, so that when the child stands or attempts to walk, one leg has to be carried around and across the other and is spoken of as "Scissors Gait." In an endeavor to straighten out any flexed joint, extreme rigidity

is noted and this is sometimes called "Lead-pipe Rigidity," as it suggests the sensation one experiences in straightening out this metallic substance. Again we note in some descriptions of this disease what is termed the "Clasp-knife Rigidity," as the part springs back into its former malposition just as a knife blade closes up. These children in severe cases can rarely stand and if they do, it is in a position with the legs crossed, knees flexed and on tip-toe. In the severe cases, it is extremely difficult for them to maintain equilibrium and the jerky incoördinate efforts at walking are most pathetic. At times in the idiotic form, a child may be four to six years of age before it can sit alone and maintain its balance. Occasionally they never attain this power. It is especially distressing to see a child with fairly good mentality unable to sit



FIG. 520.—Extreme muscular contraction in a case of paraplegia before operation.

alone, stand or walk. Some of these children have a condition of porencephalus or "hole in the brain" from absence of cortical motor substance.

Paraplegia is more often seen than the other varieties and is the result of injury at birth and constitutes by all odds the larger proportion of the cases that seek the aid of the surgeon, because to all intents and purposes they are mentally less defective and their chief difficulty consists of inability to stand or walk. In addition to the malposition previously described, one more often sees when the equinus clement has been corrected in these cases, a marked abduction of the fore-foot with *pronation*, from laxity of the anterior and posterior tibial group and over-action of the peronei.

Pathology.

The cerebral defect found at autopsy will depend largely upon the type of this disease that has existed. In Hemiplegia, Osler described embolism,

thrombosis and hemorrhage; atrophy and sclerosis and porencephalus. Of these, atrophy and sclerosis form 50 per cent. Plugging the large sylvian artery and hemorrhage form quite a group. Of course, the more extensive



FIG. 521.—The same

the distribution, the wider would be the atrophy and sclerosis. Porencephalus or a hole in the brain, represents a loss of brain substance, more or less widespread dependent upon the initial lesion. Strumpell compares this disease in the



FIG. 522.—Extreme flexion at wrist in spastic diplegia.

brain to the destruction and atrophy of the anterior multipolar cells in the cord in Infantile Paralysis and gives this the name of Poliencephilitis. In Bilateral Hemiplegia, of course, both sides are involved. In retarded or defective

development of the brain substance, the presence of scar-tissue is somewhat similar to that we find as a result of injury or disease. The remains of an old clot or organized connective tissue may be present in the region of the longitudinal sinus.



FIG. 523.—Cerebral palsy, diplegic wrist drop, before tendon lengthening. (*Young.*)

Diagnosis.

The characteristic symptoms of this disease should afford no serious difficulty to recognition after once one has become familiar with the type.



FIG. 524.—Cerebral palsy, contracture of foot. (*Young.*)

Differential Diagnosis.

Infantile Paralysis shows flaccidity, loss of reflexes and decreased or lost power and atrophy. Whereas Spastic Paralysis has increased reflexes, increased power, undue rigidity and but little atrophy. Incoördination also marks the latter. Occasionally a cerebral tumor may give rise to symptoms quite like Birth Palsy, but tumors are more often seen in later life than in childhood.

Cerebellar tumors give rise to instability and staggering, but these are also seen later on and do not date from birth or early life. Pseudo-hypertrophic paralysis may show some spasticity early in its development.

Prognosis.

The prognosis depends upon the degree of the cerebral defect or lesion. Modern operative procedures on the tendons, muscles or the peripheral motor nerves yield satisfactory results in the correction of deformity and partial restoration of function in milder and medium grade cases. Even children, who have been decidedly backward mentally, receive a great stimulus when they are enabled to walk and play around with other children.



FIG. 525.—Moderate degree of diplegia.

Treatment.

Immediately after a prolonged instrumental or abnormal labor, if the child shows deformities and increased reflexes suggestive of Spastic Paralysis and one suspects cortical hemorrhage, consultation should be had with the best obtainable neurologist and neuro-surgeon at the earliest possible moment, with a view to craniotomy for the arrest of the hemorrhage and removal of clots. Delay must of necessity lead to intracranial pressure with impairment of the motor functions, dependent on the extent of the traumatism. Life-long misery to the child and parents may possibly be avoided only by prompt consultation and in most of these cases that persist there is life-long dependence, requiring a nurse or care-taker. In the congenital microcephalics and idiots, but little can be hoped for, they were better dead for the interests of all concerned, but if any reasonable doubt exists, consultation should be sought.

Should such aid be out of reach or unobtainable for any reason, the medical adviser should at once resort to all means available for the arrest and prompt absorption of the hemorrhage such as rigid quiet, both in regard to noise around the infant's environment and the strict avoidance of moving the child out of its crib for any purpose whatsoever.

Ice bags to the head and heat to the body should be applied, bleeding, counterirritation and the use of morphine or some form of opium in very minute

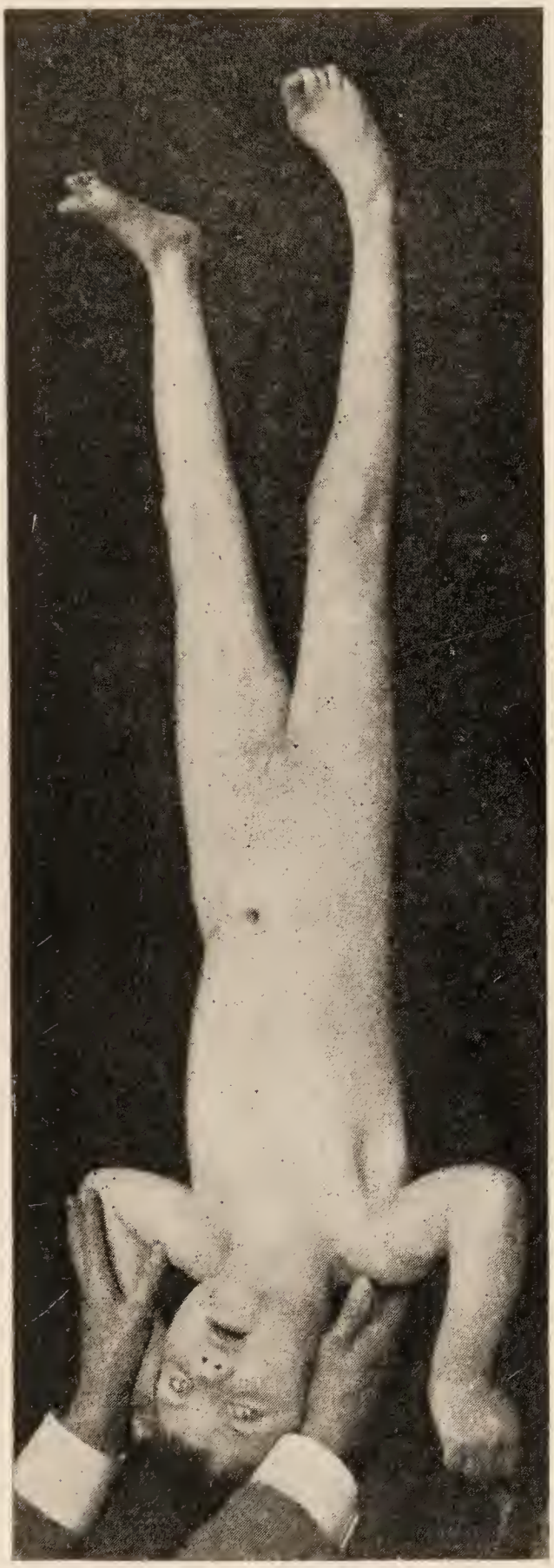


FIG. 526.—Congenital diplegia. (*Young.*)



FIG. 527.—Severe case of congenital diplegia. (*Young.*)

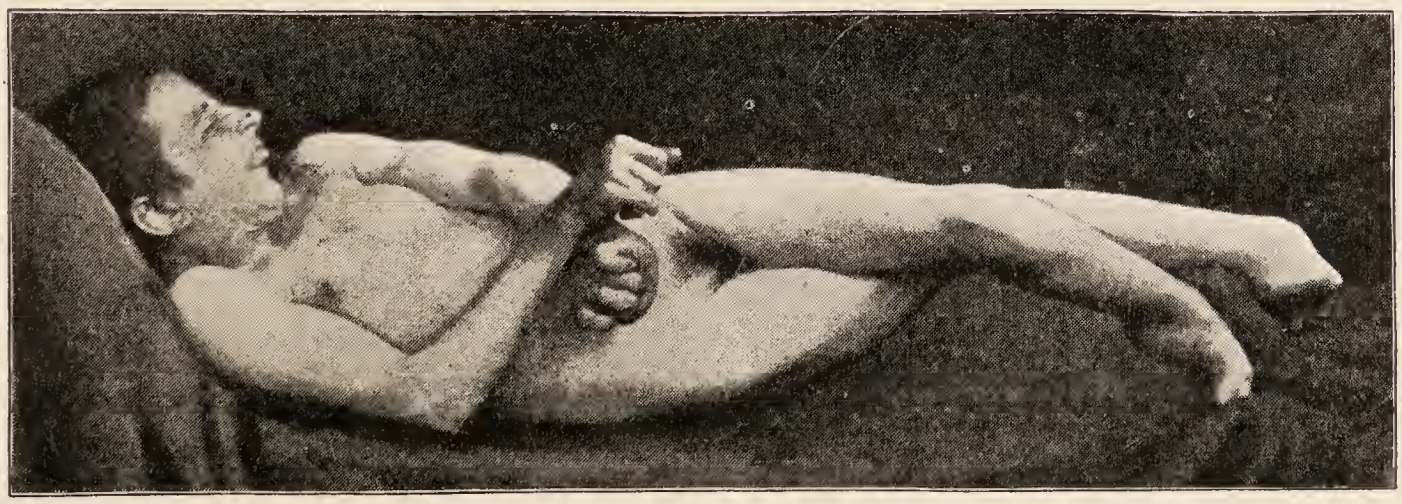


FIG. 528.—Extreme spastic contractures in upper and lower extremities in severe case of birth palsy. (*Young.*)

doses may be tried. In cases of extreme severity, adrenalin chloride solution (1:1000) in cubic centimeter doses daily may be given intravenously or intraspinously or even through the fontanelles superficially just within the skull in the suspected area. Decompression and ligation of all bleeding points may be warranted. Undue escape of cerebro-spinal fluid is to be avoided owing to the post-operative tendency to hyperpyrexia. Sharp of New York suggests that the post-operative control of this high fever can be aided by inversion or placing the child's head much lower than the body by means of pillows under the trunk and legs. In doing a decompression, one should first look for an extra-dural hemorrhage in the longitudinal sinus and not open the dura, if avoidable.

Treatment by Tenotomy or Myotomy.

Since the introduction of Tenotomy and up to 1912, the operation of choice for the later deformities has been division of the contracted tendons or muscles in these conditions and placing the limbs in correction or over-correction in casts or splints for a month or more. The results were fair, but in certain instances recurrence of deformity was noted from a recontraction of the offending muscle. The muscles and tendons usually tenotomized were all of the adductors, the hamstrings, the tendo achillis, the transference or myotomy of the pronator radii teres and possibly the biceps of the arm.

Tenotomy of the Adductors.

This procedure is, of course, done in a sterile field, usually having the child prepared the day before and the part kept wet with a bichloride towel until the time of the operation. Both legs are abducted by the assistants, as far as possible, making the adductor tendons stand out as a ridge. The tendon of the adductor longus is located by palpation at about ½ inch below the pubic tubercle. With a sharp tenotome directed downward and medially and the blade parallel with the long axis of the adductor longus tendon, a puncture is made under each on the lateral side. The sharp tenotome is then withdrawn and the blunt tenotome is inserted and rotated through an arc of 90°, so that the cutting edge is against the tendon. By a gentle sawing motion as the assistant continues to abduct the leg, the tendon is entirely severed. Similarly, the tendons of the adductor magnus, adductor minimus, adductor brevis and gracilis are divided through the small puncture wound. Resisting bands of tendon are readily detected by palpation through the skin with the index finger of the left hand. The puncture wound is then closed with silver foil and gauze is applied in the usual manner. Maintenance of the abducted position is preferably obtained by a double plaster of paris spica, if only the adductors are at fault. Frequently, however, the hamstrings and achilles tendons have to be divided and in that event, the plaster casts are carried from the tips of the toes to the groin only and the abduction is maintained by having a stick three to four feet long attached to the feet by turns of plaster of paris, which thus avoids the necessity of carrying the plaster of paris bandage around the pelvis as a spica, an advantage of no little importance in an uncleanly child. In the latter case, the gauze dressings can be held in position by surgeon's plaster.

Tenotomy of the Hamstrings.

This procedure is done to overcome the spastic contracture of these muscles, which are over-stimulated to the detriment of the quadriceps extensor femoris, so that the patient stands and walks, or maintains balance constantly or even when seen recumbent is, in a permanent position of flexion of the knees.

Tenotomy of these muscles is usually done one or two inches above the flexure of the knee. By some, it is done subcutaneously just as the adductors are done, but this procedure in regard to the biceps is attended with danger to the perineal or external popliteal nerve, which lies immediately anterior and medial to the tendon at this point. Therefore, it is much wiser to divide these tendons through open incisions, which are made immediately over the taut tendons on each side of the popliteal space. These incisions need not be over one or two inches in length and after division of the deep fascia, each tendon comes readily into view, a grooved director may be slipped under each and it can then readily be divided and the knee straightened. As a rule, suture of the deep fascia is unnecessary and the skin wound is closed subcutaneously with #2 chromic cat-gut, which, of course, does not require subsequent removal, as is the case with silver wire, silk or silk-worm gut. The wounds are covered with silver foil, gauze and glazed cotton. A plaster bandage holds the knees in a fully corrected position. When the mal-position has been in existence for some time, considerable force may be necessary, even after free section of the tendons and as well as the deep fascia, to fully extend the knees.

Tenotomy of the tendo achillis and also Tenotomy of the peronii have been fully gone into in the Chapter of Deformities of the Feet, so that further details of this will not be given here.

Tenotomy of the muscles in the arm for contracture of the elbow, wrist and fingers are rarely resorted to. Much can be accomplished by stretching and muscle-training with splinting in the interim between treatments. For the extreme supination of a rigid character that one often sees in this condition, Hoffa and others have recommended the detachment of the insertion of the pronator radii teres from the anterior and lateral aspect of the radius and passing it through the interosseous membrane and giving it attachment on the dorsal and lateral aspect in an endeavor thereby to convert it into a supinator. Another procedure suggested by Hoffa was to detach the humeral head of the pronator radii teres from the internal condyle of the humerus, passing it through the subcutaneous fat and suturing it to the external condyle of the humerus. All of these procedures, as previously stated, are disappointing as compared with the sections of motor nerves about to be described.

Neurectomy.

For the relief of the spastic contractures and the restoration of power in the opposing muscles, which have evidently been over-stretched, Adolph Stoffel, formerly of Heidelberg and now Professor of Orthopaedic Surgery in the University of Mannheim, published an account of his work for the relief of this condition on Volume 10 of the Journal of Orthopaedic Surgery in 1912, page 611. In this article, he states that he had been engaged in this investigation for several years. He had previously published articles bearing upon allied subjects.

Stoffel states, "The cause of spastic contractures is found in an affection of the cortical spinal conduits, the most essential of which in the human body is the pyramidal tract. According to Förster's investigations the pyramidal tract has two functions; firstly, it conducts the impulses of volition from the cerebral cortex to the spinal gray matter, and secondly it inhibits the spinal reflex excitability by maintaining the latter on that level, which we know in normal man. If any kind of noxious influence affects the pyramidal tract, the inhibitory fibres of the pyramidal tract are injured much earlier and much more severely than the innervating fibres, the paretic component in many cases even disappears entirely behind the spastic component.

"If now the sensory stimuli constantly flowing to the spinal gray matter are no longer weakened or subdued by the inhibitory fibres of the pyramidal tract but pour out their full strength upon the muscle, there is set up a hypertonicity in the whole musculature of the member. If through external circumstances the places of insertion of a muscle in such a member are approximated for a long time, the tonus of this muscle is still more increased and an abnormal tension develops in this muscle. The member, consequently, is fixed by this muscle in a definite position and opposes a resistance, which is often insuperable, to every motion in the opposite direction.

"Remembering the bed position of an affected child (feet in pes equinus position because of the weight of the feet themselves and the pressure of bed coverings; legs close together, knees drawn up perhaps, forearm in pronation, etc.) we can understand that in most cases quite definite muscles and groups of muscles are the places naturally preferred for spastic symptoms. I will mention here the triceps surae, the femoral adductors, the flexors of the leg, the pronators of the forearm, etc. These muscles in a spastic condition answer all stimuli with an excessive amount of force, with unchecked action. They subdue and disarm the antagonists. They absolutely disturb the equilibrium of muscle.

"We must strictly distinguish between a spastic contracture, as the expression of an hypertonicity or increased active tension of the muscle, and the atrophic contracture, based on a change in the tissue condition, a contracture especially of the tendinous parts of a muscle. Both forms of myogenous contracture can be clearly differentiated; a spastic contracture disappears in a warm bath, after long rest (often only partially) and above all in narcosis. I am always surprised to see how slight atrophic contracture is in children and young people even in a high graded spastic contracture.

"Now, how can we exclude the predominance of the spastic muscle, how regulate its tension, i.e., reduce it to a measure that will make antagonistic coöperation possible? Before I begin to answer this question I must mention my investigations[1] on the structure of muscles and nerves, since many things would be unintelligible without them. I demonstrated that the individual muscles of anatomical nomenclature cannot be thought of as units either from an anatomical or physiological viewpoint. The reverse is true. We can separate the muscles in several sections, each one of them again subject to subdivisions. We have to conceive the up-building of muscles as follows: Many muscle units (as such I designate the aggregate of muscle fibres innervated by the ramification

[1] Verhandlungen der Deutschen Gesellshaft fur Orthopadiche Chirurgie, 1912.

of *one* nerve fibre, therefore, the nerve of a motor-ganglion cell) form a muscle division; several divisions make up a muscle complex. Several such muscle complexes compose the whole muscle. If two or more muscles are joined together, we obtain a muscle group. The triceps surae and brachialis, the biceps of the arm and thigh, the quadriceps, deltoid, pectoralis major, pronator teres, etc., must be conceived of as muscle groups.

"The nerve is built up in perfect analogy to the muscle. The nerve unit is the nerve fibre, the nerve of the motor ganglion cell. Several nerve fibres unite to form a small funiculus. Several funiculi collect into a branch. The nerve of a muscle represents the sum of branches. The perfect analogy in the structure of muscle and nerve is, therefore apparent, both being composed of single small units, gathering into combinations which are constantly growing in size. Each one of the funiculi and branches of a nerve supplies motor fibres to a very definite portion of a muscle. They are independent formations, representing a smaller or larger total of nerve fibres which reach from the motor ganglion cells in the anterior horns to any given portion of the muscle. If one should sever one of these funiculi at any place in its course, or if one destroyed its motor ganglion cells in the anterior horn, one would obtain an isolated paralysis within the muscle group of those portions of the muscle which are supplied with motor fibres by the respective funiculi.

"Sometimes nature conducts the just described experiment herself, only in the opposite way. In operations on children, e.g., those who have gone through a poliomyelitis, we notice frequently that a totally degenerated muscle shows right in the middle of its yellowish-white substance, an island consisting of red, sound-looking muscle fibres. How can such a condition be explained? Evidently only by the assumption that the anterior nerve cell of the motor-nerve funiculus, which is responsible for the innervation of this healthy muscle island, were not destroyed by the poliomyelitic inflammatory process, but remained intact. Within the motor nerve of this muscle, therefore, all nerve funiculi are now conducted, the appropriate ganglion cells being destroyed, only a single funiculus represents the connection between special substance and muscle. This fact is brought into existence by the red muscle islands.

"We would obtain a similar result in a muscle if we severed all funiculi in a motor nerve, leaving only one intact. All parts of the muscle, which correspond to the several funiculi, would then degenerate, and only that particular portion, the funiculus of which is untouched, would retain its natural aspect and functionability.

"Anastomoses between adjacent nerve tracts are rarely found either in the muscle or between the motor nerves and the large peripheral nerve trunk. Many anatomical investigations convinced me of this. How a muscle is supplied with sensory fibres is up to the present time, very little known anatomically.

"If a muscle is made up of several parts, its total energy represents the aggregate of the effects of these parts. If we want to lessen the aggregate energy of a spastic muscle, we need only reduce the number of its parts. Assuming for example that a muscle consisted of 50 equal parts, developing thus an energy of 50, its energy would sink to 40 if 10 of its parts were destroyed.

If this energy of 40 corresponded to that of a normally innervated—therefore not spastic—muscle, we would have reduced the muscle energy to a degree which makes antagonistic coöperation possible.

"Now, how can we isolate single parts in a muscle? By severing and resecting the motor funiculi of these parts; which can be accomplished in various places in the course of the motor-nerve tract. The simplest case is that of a muscle in which we can follow the motor nerve to its place of entrance into the muscle, for example, in the heads of the gastrocnemius. Thus we can without trouble separate the motor nerves in several funiculi and can resect some of them. If it is not possible to reach the motor nerve at its place of entrance into the muscle, for example, in the four heads of the quadriceps or the flexors of the legs, then our procedure is to split up the muscle nerve at any suitable place in its course into its single fibres, and to resect some of them. If we cannot very well get at the motor nerve of a muscle, we carry out our neurectomy upon the respective large peripheral nerves. If for example we wish to weaken the pronator teres or the flexor carpi radialis, our knife attacks the median nerve in the distal half of the humerus. Or, if the energy of the flexors of the forearm on the longi digitorum is to be reduced, we pick out the particular nerve tract in the musculocutaneous group and rob it of a portion of its fibres."

We may compare the whole situation to an electric-bell with pressure on the push-button, which latter represents the cell in the brain from which a given nerve arises and the muscle the bell. The bell will ring as long as the pressure is made and there is no inhibition. If there is lost inhibition to the stimulus of the brain cell and as we cannot locate or operate on the brain cell usually, we must cut some or many of the nerves to the offending muscle."

Stoffel's Operation for Spastic Adduction.

An incision two or three inches long is made over the tendon of the adductor longus and after cutting through the deep fascia, this tendon is retracted in a medial direction opening up the line of cleavage between it and its external neighbor, the pectineus, between which will be seen, lying deeply, the main trunk and two or three branches of the anterior division of the obturator nerve, close up and external to the tubercle of the pubis, which then comes into view. Two or three branches are seen given off to the adductor longus and magnus muscles. The main trunk is lifted up with a glass dissecting hook and its identification is positively estimated by stimulation with an electric needle or by pinching with smooth faced forceps. When assured of its nature, it is cut off close up to its origin and ½ to ¾ of an inch of the nerve and its branches are resected. The wound is then closed up by close approximation with #2 plain cat-gut to the fascia and #2 chromic cat-gut applied subcutaneously to the skin. Preferably in feeble-minded or restless children, silk-worm gut or silk interrupted sutures to the skin are closely applied. In those that frequently soil the gauze, it is desirable to paint the wound with iodine or cover it with flexible collodion prior to the application of the gauze. The remaining branches of the obturator consisting of the posterior division give ample innervation, but destroy the undue power of adduction. Almost immediately after the child regains consciousness, it will be observed that the deformity is corrected and

parallelism of the legs is restored. In 10 days or two weeks after this operation, if the necessary and coöperative degree of mentality is present in the case, the child will be able to walk in a much more normal way than ever before.

Stoffel's Operation for Spastic Knee Flexion.

For the correction of this condition, Stoffel recommends an incision (at a point mid-way between the trochanter and the tubercle of the ischium) on the posterior aspect of the thigh just about the fold of the buttock extending downward three or four inches. This usually reveals the point lying deeply after division of the deep fascia, where the sciatic nerve gives off two or three branches to the semitendinosus, semimembranosus, and at a little lower point, but on the anterior and lateral aspect of the sciatic, one is able to demonstrate with the electric needle, the branch that goes to the biceps. These fasciculi are picked up, stimulated and resected, as were those of the obturator, usually with the immediate and permanent relaxation of the hamstrings and the equalization of the balance of power between the quadriceps group and the flexors of the knee. Sufficient innervation is left by this procedure not to destroy the power of voluntary flexion of the knee. As pointed out by Stoffel, we usually find in these cases a spastic contracture that disappears in sleep and under narcosis, but occasionally what he terms an atrophic contracture referring to the length of the muscle, which has been in existence for such a prolonged time that actual "adaptive" muscle shortening has occurred and section of the motor nerve is not adequate to correct the deformity absolutely. No alternative, therefore, is left then in such a condition, but to supplement nerve section with division of the hamstring tendons, as previously described, in order to get a straight limb.

Stoffel's Operation for Spastic Talipes Equinus, Talipes Equino-varus and Talipes Equino-valgus.

These procedures call for operative incision in the centre of the popliteal space. After division has occurred between the internal popliteal and external popliteal nerve, or, as they are now known, as the tibial nerve and the perineal, usually in the upper part of the internal popliteal nerve, branches are seen to be given off on each side from this nerve, which go directly into the two heads of the gastrocnemius. These are resected with the relief of the equinus deformity.

This nerve is readily exposed, as it lies immediately under the skin and deep fascia in the centre of the popliteal space. For the relief of the valgus or varus deformity, the tendon of the biceps muscle is to be our guide in finding the perineal nerve, the sheath of which is carefully opened with a pair of very fine angulated scissors and the undivided fasciculi are brought into view. When carefully separated, they can be lifted carefully with a small glass dissecting hook and tested with the electric current to locate whether it goes to the perineal or anterior tibial muscles by stimulation and is then resected, when the lateral deformity will be corrected. Occasionally, one has to divide the contracted peronei tendons at the external malleolus to obtain normal position and promote normal function.

Perhaps the most brilliant results, both in restoration of position and function are obtained from the resection of branches of the median nerve whose over-

action produces conspicuous deformities and abolishes the possibility of anything approaching normal function in the arm. The median nerve is readily accessible on the middle of the front of the elbow, lying just internal to the tendon of the biceps, which latter is retracted laterally. On the medial side of the nerve will be seen two branches, which go to the pronator radii teres and section of which usually will relieve the over-action in pronation that is always present and prevents bringing the palm of the hand to the mouth. Further down, one encounters also on the medial side branches of the flexor carpi radialis, the palmaris longus and the flexor sublimis digitorum, which if offenders in the production of the deformity, must be resected. If in rare cases, one finds spastic rigidity in the biceps, branches to this muscle from the musculocutaneous nerve can be located just above the centre of the muscle on the medial side and come into view when the muscle is retracted in a lateral direction. Resection of these branches will give the desired result. In certain instances with extreme adduction of the thumb, the ulnar nerve is to be exposed just above the wrist, its sheath opened and the fasciculus going to the thumb is to be differentiated and resected. The restoration of the use of the arm, especially the right arm, in these spastic cases is one of the most satisfactory procedures at our command.

The glass hook is used in these dissections to avoid conduction of the electric stimulating current to other nerves. The nerve should be kept moist with a few drops of normal salt solution but the wound should not be flooded with it, as the liquid acts as a conductor also. As weak an electric current as possible is to be used so as to avoid stimulation of nerves not under investigation.

Many neurologists claim that Stoffel's operation does not diminish the innervation to a muscle, but paralyzes the muscle bundles to which the sectioned nerve filaments go. Thus if two branches go to a muscle and one is resected motor power remains in only half the muscle which still has central connection.

The neurologists consider the Förster operation of section of the posterior nerve roots the more scientific. This entails after laminectomy, intraspinal section of the posterior nerve roots dorsal to their ganglia, thus breaking up the reflex circle or chain in cases where the central control through the pyramidal tracts is impaired or lost, the spinal cord reflexes are uncontrolled and this chain is broken by section of the inflowing sensory stimuli. After laminectomy, exposing the dura and identifying by electrical stimulation the posterior nerve roots at fault section is to be done. This operation should only be undertaken by a neurological surgeon or one skilled in spinal cord surgery. In the majority of cases tenotomy and myotomy, especially those not mentally impaired are the operations of choice.

CHAPTER XXIV

MUSCULAR DYSTROPHIES AND MYOPATHIES

Pseudo-hypertrophic Muscular Paralysis.

This condition is characterized by an apparent enlargement of the calf muscles more often in male children from the eighth to the twelfth year and followed by a progressive decrease in power not only in the calf muscles, but in those that control the shoulder girdle as well. These cases are usually first seen walking with a slight limp and showing especial difficulty in arising from the floor, so that after assuming a kneeling position when a foot is placed upon the ground, the child has to pull the body into an upright position by "climbing up its own legs" with its hands on its thighs. One also notices that the child has great difficulty, if it is not actually impossible for them to go up stairs owing to the extreme weakened power in the quadriceps extensor femoris. Later, if these cases are followed, contracture of the achilles tendon will be noted and an equinus position has occurred, which may require division of the tendo achillis and the wearing of an ankle supporting brace to prevent recontracture. Still later these patients may be dependent upon a cane in order to progress. Later on the lumbar muscles become involved and locomotion is practically impossible, so they become wheel-chair or bed-ridden cases. As has been stated, about five males are seen with this affection to one female. There is usually an hereditary incidence through the female side, although the mother may be exempt from the disease of her offspring. It is supposed to be due to a degenerative atrophy of the nerve terminals or of the muscular fibres. themselves with a replacement of true muscular tissue by fat and connective tissue (Figs. 529 and 530).



FIG. 529.—Case of pseudo-hypertrophic muscular paralysis, early stage. Note enlarged calves. (*Young.*)

Symptoms.—These patients suffer but seldom from any neuritic pain and virtually have no symptoms except increasing disability in locomotion and in the use of the arms. Later, from increasing weakness, deformities may occur such as Talipes Equinus, flexion of the knee, lordosis with prominent

abdomen and prominent scapulae with contracture of the antagonistic groups of muscles.

Diagnosis.—This is usually made in the early stages from the abnormal enlargement of the calves of the leg and the difficulty the child experiences in getting up off the floor and ascending stairs (Figs. 531 and 532).

Treatment.—Massage, muscle training and electricity have some influence in retarding the progress of the disease (Figs. 533 and 534).



FIG. 530.—Two cases of progressive muscular atrophy, the boy on the right cannot stand erect as the disease has progressed; the erector spinae, thomboids and quadratus lumborum are involved and the feet are in Equinus. Note enlarged calves.

Three sub-divisions of this condition are described.

First, the Erb Type is seen in the shoulders and neck, usually between the twelfth and sixteenth year, which involves the pectorals, deltoids, rhomboids and trapezii with the deformities one would naturally expect from weakness in these parts.

Second, the Landouzy-Dèjerin Type, in which the atrophy begins in the muscles of the face. The lips are weak and everted and the mouth stands open causing the so-called "tapir mouth." From this point, the disease extends to the neck and shoulders.

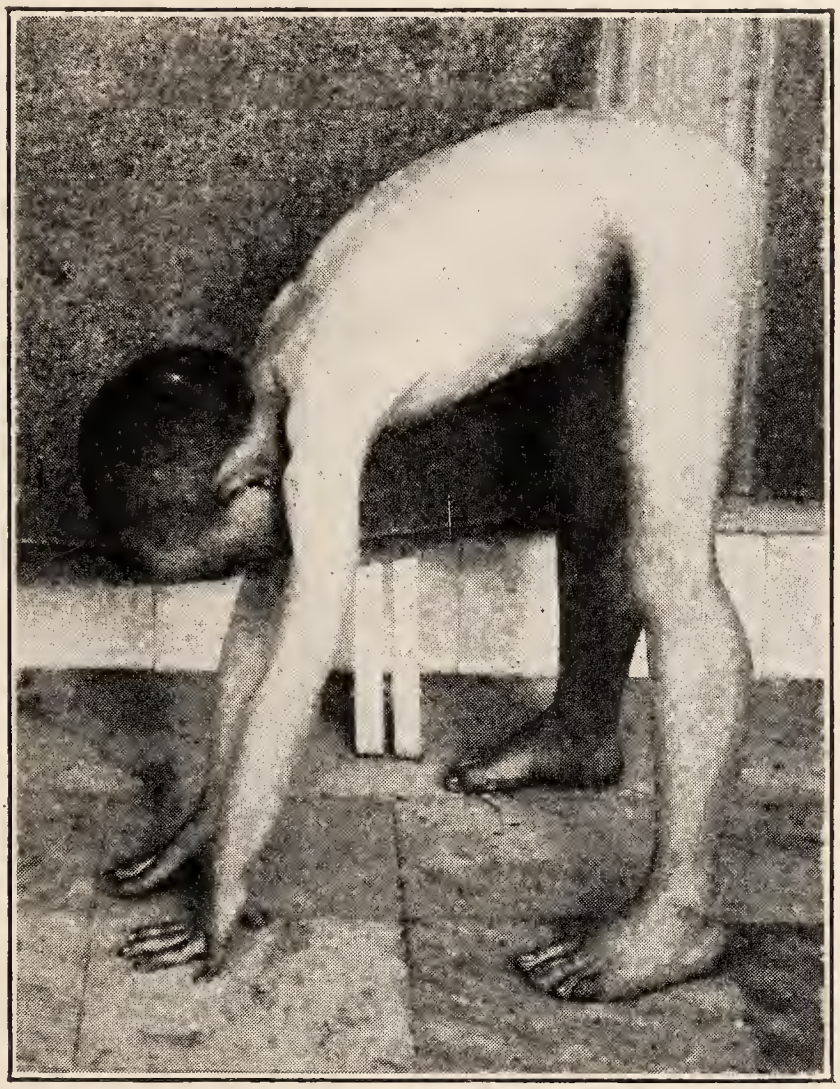


FIG. 531.—After sitting on the floor these cases of psuedo-hypertrophy assume a kneeling attitude from which they pass to the quadripedal position shown in cut, in an endeavor to stand erect.

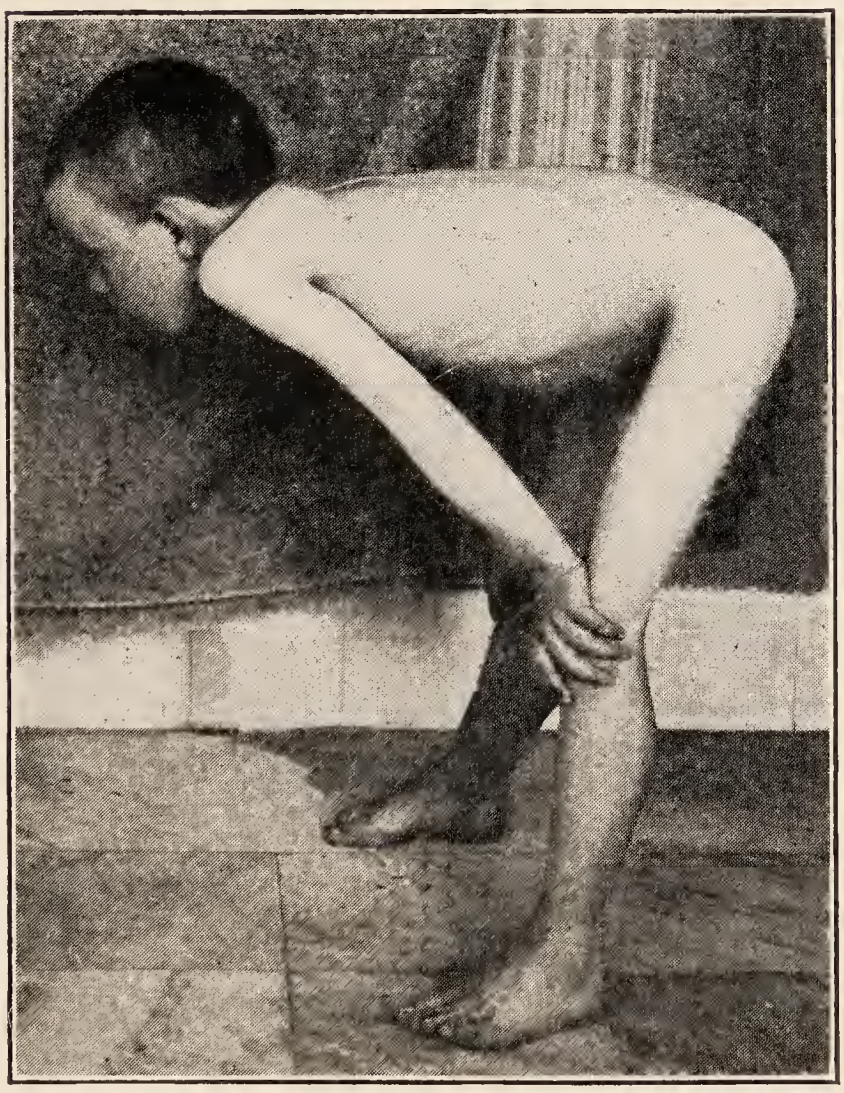


FIG. 532.—From the posture shown in Fig. 531, the upright position is attained by pressure on the legs by the hands and arms or the characteristic "climbing up the legs."

Third, the Perineal Type, called also the Charcot-Marie-Tooth Disease. This affection first appears in the peronei, extensor proprius hallucis or extensor communis digitorum. This naturally leads to deformities of the leg. Later on, the hands become deformed and the characteristic "clawhand" is seen.



FIG. 533.—Last and severest stage of pseudo-muscular hypertrophy in a girl. Extreme degree of amyotonia. Patient can neither stand nor walk. Note extreme lordosis from atony.



FIG. 534.—The same.

Infectious and Traumatic Myositis.

The muscles, like other parts of the body may be secondarily involved as sequilae of the eruptive fevers and serious muscular disability may also naturally occur from rupture or contusion. Appropriate treatment, such as ice bags, rest, immobilization or suture will suggest themselves to the surgeon based on the history and diagnosis.

Ischemic Paralysis or Myositis.

This condition was first described by Von Volkmann in 1875 and is more commonly seen after fractures in the arm, which have been treated by the too tight application of splints or bandages interfering with the circulation. The nutrition of the muscle is so seriously interfered with, that necrosis of the muscular tissue occurs and scar tissue takes its place. The diagnosis is easy

from the history of the case and from the position of the deformity of wrist drop, semi-pronation and flexed elbow, such as one sees somewhat similarly in Spastic Paralyses. The prognosis is poor for restoration of normal function. The treatment consists in appropriate tendon transplantation of the muscles left, to functionate for those that have been destroyed. For example, the flexor carpi radialis is transplanted into the extensors of the thumb and index finger and the flexor carpi ulnaris is inserted in the remaining fingers. Hoffa's operation on the pronator radii teres previously described has been used to overcome the pronation.

Myositis Ossificans.

This is a condition in which the muscles undergo calcareous degeneration, usually following some trauma, especially fractures. It is seen as a localized condition, usually, but in some cases it is progressive. If localized, the treatment consists of its resection (Figs. 375 and 376). It is more common in fractures near the elbow with tearing and stripping up of the periosteum. It has been reported in a case after abdominal operations associated with acid discharges.

Progressive Muscular Atrophy.

As its name implies, this condition consists in a progressive wasting of the muscles of the extremities and trunk until the patient finally becomes bedridden or forced to remain in a chair. It consists of two forms, the Myelopathic form, in which the primary disease is apparently in the spinal cord and the myopathic form, in which the disease appears to be primarily in the nerve terminals and muscular fibres. It is to this second variety that Pseudo-Muscular Hypertrophy belongs, which has been previously described.

Friedreich's Ataxia.

This is an hereditary affection characterized by chronic degenerative disease of the posterior and lateral columns of the spinal cord, occurring in adolescence. It is sometimes called Hereditary Ataxia from the fact that it occurs either directly or indirectly from parent to child in those of a neurotic tendency. Syphilis, consanguineous marriages and tuberculosis have been given as causes. It is quite similar in its pathology to Locomotor Ataxia, usually beginning in the lumbar region and extending upward and downward. The gait is weak and staggering, the motions are incoördinate, the reflexes are lost and deformities occur from muscular inbalance. A gradual mental deterioration is at times noted as the muscular weakness increases. Massage, electricity, braces and operations, such as tenotomies afford only temporary relief.

CHAPTER XXV

ARTHRITIS, MOBILIZATION OF STIFF JOINTS AND ARTHRODESIS

Many people, who are greatly handicapped by stiff joints, the result of trauma or infection, present themselves to the surgeon for relief.

Arthroplasty is an operation on a joint whether for exploration, removal of a foreign body or unhealthy growth for purposes of restoring function.

Arthrolysis is the operative treatment to overcome ankylosis.

Stereo-Arthrolysis is a term sometimes applied to indicate an operative procedure to loosen a solid joint, namely bony ankylosis.

False Ankylosis is a stiffness in a joint produced by muscular rigidity or spasm, such as we see in acute tubercular joints or following an acute infectious arthritis with an extreme degree of peri-articular thickening of the capsule.

True Ankylosis may be fibrous or bony or cartilagenous. Rarely in Tuberculosis do we see bone proliferation and the type of ankylosis is more often fibrous, which has to undergo a slow process of metaplasia into fibrocartilage and then transformation to bone. In certain acute or infectious osteo-arthritides, one sees an agglutination of the synovial membrane, stimulation of the perichondrium with new cartilage and bone formation and locking of the joint by a bony ring. After fibrillation of the cartilage in acute processes osteoblasts from the bone marrow may invade the joint and lead to bony ankylosis.

Sir Robert Jones cautions us, that in breaking up adhesions in synovial agglutinations or fibrous adhesions in joints, with or without anaesthesia that one should not use the limb as a pump handle to work up and down, but break the adhesions *once*, for fear of extending the abraded surface.

Arthritis, Its Prevention and Treatment.

Arthritis, Osteo-arthritis, Arthritis Deformans, Infectious Arthritis and Chronic Rheumatism are synonymous terms applied to the very common ailment leading to stiffening of the joints. Physicians also at times speak of it as "Still's Disease" in children and as Hypertrophic or Atrophic Arthritis.

It is usually classified etiologically as (1) Traumatic, (2) Infectious and (3) Metabolic. In the writer's experience and upon that experience his opinion is based, that Infectious is more properly the term best applied to all. If a patient traumatizes a joint and that patient has a focal infection elsewhere, this injured point of least resistance readily lends itself to degenerative and proliferative changes. It is in this type we more frequently find monarticular arthritis.

In that much more common variety, which is more and more spoken of as Infectious, we usually find symmetrically and morphologically nearly similar appearances in the right and left extremities varying slightly in degree of involvement. With a *complete survey* of the individual, the focal source of infection is more often than not found, although it is believed by many when once

the Arthritis becomes generalized, each involved joint may in turn furnish the focus from which other joints may become involved. Conversely when the initial source of infection is found and removed many of the already infected joints show signs of improvement, if not actual restoration. This is noticeably true in stiffness and involvement of the cervical vertebrae in arthritis from carious teeth with apical and alveolar abscesses.

The infectious sources of Arthritis may, in their order of frequency, be listed as follows:

(1) Apical and Alveolar Abscesses from defective teeth, which include those in which the nerve has been killed or has died or those in which the root canal has been only partially filled. Crowned teeth, pivot teeth, teeth affording unscientific support to "bridge-work" should all be under suspicion and carefully examined clinically and by the X-ray. Often such an abscess may involve an extensive bone area in the inferior or superior maxilla, extending to or into the antrum in the latter. Cultures more often yield the Streptococcus, of which the non-haemolytic viridans is the variety most often encountered.

(2) Old troublesome tonsils come next in frequency as a source with a history of frequent attacks of sore throat. They may not be hypertrophic and often are imbedded, under which is the abscess surrounded oft-times by scar tissue. The streptococcus here is often the offender also.

(3) Old Gonorrheal Prostatitis.
(4) Pyorrhoea Alveolaris.
(5) Antra or Frontal Sinus Infection.
(6) Chronic Post-pharyngeal Catarrh.
(7) Purulent Diarrhoea or Chronic Colitis.
(8) Chronic Appendicitis, Mastoid or Otitis Media.
(9) Any suppurating focus elsewhere.

The Metabolic variety still has champions, notably Pemberton, but in the writer's experience with the exception of Gout and its Heberden's Nodes, diet plays but little part in causation or cure in Arthritis. There is nothing to prevent a chronic dyspeptic from being the victim also of a focal infection in a joint and such a patient must be dieted. Buttermilk, yeast, regulated calories and non-carbohydrate diets have had their vogue. These therapeutic agents were popular for a shorter time and had less widespread acceptance than the present Infectious theory, as the Metabolic case has not been proven to the satisfaction of a large number of clinicians.

The varieties of clinical Arthritis are divisible into those seen in childhood and those in middle and old age. In the former, Still's Disease as it is known may involve in the same individual the ankles, knees, hands, elbows, spine and hips in the order named or all at the same time. Occasionally the temporomaxillary joint shows stiffness.

The joints are fusiform in shape from periarticular swelling and not from bone hypertrophy, as the reverse or bone atrophy is the rule. The X-ray shows clouding of the joints with some osteoporosis. This is the so-called Atrophic variety. This type is also accompanied by cervical, inguinal or axillary glandular enlargement, as well as presenting palpable livers and spleens.

In the type seen in middle and advanced age, we more often see in the X-ray atrophy of a portion of a joint with hypertrophic new bone formation in the peripheries, as osteophytes or exostoses and roughening, which is quite characteristic. These furnish the Hypertrophic variety. The hands become deviated at the metacarpo-phalangeal joints in an ulnar direction. (See Figs. 384 and 385 of the two types.)

Prevention.

As prevention here is easier than cure, it is the duty of physicians and health officers to impress on their clientele and charges the importance of complete bodily survey three or four times a year to eradicate any infectious focus "in the borning" and thus save individuals from Arthritis with synovial and articular destruction later, as well as prevent other ailments. The abused term "Rheumatism" and delay in treatment with the attendant dangers should be more and more stressed to the public, if crippling and deformity are to be avoided.

Treatment of Acute Infectious Osteo-arthritis.

Fixation leads to ankylosis in an infected joint, therefore rest and non-use of the joint with avoidance of fixation by a plaster cast or other apparatus, should be the procedure, in so far as the patient's suffering will permit. It must be realized that inflamed, swollen synovia and later eroded cartilage and exposed bone may be opposed by a similar condition in the adjacent component of the joint, so that any friction between the two causes pain. At the same time, as much voluntary motion, without weight bearing, as is consistent with comfort, should be used by the patient to prevent ankylosis and promote circulation. This is a disease more often of the idle well-to-do and the working man and working woman improve the repair by improved circulation by use short of pain.

Warmth by flannel, baking by electricity or gas, wet dressings, preferably of some stimulating or absorbing lotion, should be used at night. No massage nor passive motions should for a moment be considered in acute joints, but unfortunately this is often the first thing done. Rest in bed and support yield more cures than *over-use*, at the height of the disease.

It is needless to say the focus of infection should be the first thing sought by the medical attendant and eliminated. At the same time an autogenous vaccine should be made and given in appropriate doses carefully, with a tendency to under- rather than over-dosing for fear of anaphylaxis. Gratifying results have been obtained when the knee joints furnished a sufficient amount of toxic synovia as an antitoxin to use in ten to twenty cc. doses, after extraction by a Luer syringe, deep into the gluteal muscles.

Traction yields good results in overcoming intra-articular pressure, muscle spasm and contractures. When quiescent and no longer painful, baking up to 300 to 350 degrees may be given once or twice daily; massage and passive motions, anaesthesia and brisement forcé or tenotomies or arthroplasties may be done to overcome partial or complete ankylosis.

Literature of Mobilization of Joints.

The treatment of ankylosis in past centuries may be described as the forcible separation of the adherent surfaces and the endeavor to maintain motion after the adhesions had once been freed (brisement forcé). This originated with Louvrier, of Paris, and Max Langenbeck, of Hanover. In a very small percentage of the cases, namely, those of synovial agglutination without organic union, the result was gratifying. In the enormous percentage of cases in which the lesions were due to necrosis of the synovial membrane, or to fibrous or osseous union of the articular surfaces, ankylosis recurred after redressment, and the limb was in as bad, if not in a worse, condition than before.

In 1826, Doctor Rhea Barton, of Philadelphia, removed a wedge from an ankylosed hip, "sawing through the great trochanter and the neck in a transverse direction." Passive motion was used after three weeks and for a time the false joint remained mobile, but gradually became fixed.[1]

J. R. Rogers, in 1830, removed a disc of bone from between the trochanters in an endeavor to accomplish the same thing. In 1838, Berard[2] advised section after the method of Rhea Barton, with passive motion afterward, for temporo-maxillary ankylosis. In 1840, J. M. Carnochan performed the operation of "maxillary pseudo-arthrosis" by division and inserting wood or cotton between the cut ends.[3] Diffenbach (Operative Surgery), Esmarch, Richet (Thesé de Concours: Des operations applicables aux ankylosis), Rizzoli and Verneuil recommended division of the bones followed by motion for temporo-maxillary synarthroses.

In 1853, Schuh freed an ankylosed patella with a chisel, but the adhesion recurred. Ollier, by forcible distension, Hueber, by mallet, and Brachi, by manipulation, were equally unsuccessful in permanently freeing the patella. Verneuil[4] on the theory of pseudo-arthroses following fractures, interposed muscle and fascia successfully in correcting temporo-maxillary ankylosis. In 1862, Doctor Lewis Sayre removed a "roof-shaped" segment from the femur above the small trochanter, with the same object in view, but the natural result followed, as we now can understand, with an improved position, but no motion. (Compare Gant's Subtrochanteric Osteotomy.)

T. Wolff (Berliner Chirurgen Vereinigung, 1895 and 1897) reported nine successful cases following what he terms "arthrolysis," i.e., incision by scalpel and chisel of all the fibrous tissue which hindered movement; Eiselsberg, in two cases in which he employed this, was, however, successful only in one, and Kocher, while in favor of "arthrolysis," modified it by putting the components of the new joint after "arthrolysis" in a position of dislocation for a week or two, when he reduced the dislocation, with the idea that the eroded surfaces had had time to heal.

Helferich, in 1899, proposed, but did not carry out, his suggestion of inserting a portion of the vastus internus between the patella and femur to prevent reunion, but had used successfully flaps from the temporal muscle in a case of bony ankylosis of the temporo-maxillary joint in 1894.

[1] North Amer. Med. and Surg. Jour., 1827, page 290.

[2] Dict. de Med., en 30 vols., 1838, vol. xviii, page 440.

[3] Lectures on Surgical Anatomy and Operative Surgery.

[4] Archives de Medicine, 1860, page 284.

Cramer[1] reported 10 cases of ankylosis of the patella alone, in seven of which the vastus internus was interposed, and six were successful.

Chlumsky, in his article[2] reasoned that, notwithstanding the good results obtained at times by the interposition of muscle and fascia, and from the reports of Mikulicz, Helferich, Leuz and Riegner, that in large joints the procedure, through failure of preservation of the interposed tissues or on account of technical difficulties, was not all that could be desired. He therefore conducted a large number of experiments based upon the interposition of such non-absorbable substances as plates of celluloid, zinc, rubber, silver, cambric and layers of collodion and absorbable material, such as magnesium, ivory or decalcified bone. In some instances there was a tendency to joint formation, but the end results were unsatisfactory on the whole.

McIlhenny[3] removed in the inferior maxilla a wedge of bone half an inch wide from the necks of the condyles just above the insertion of the external pterygoids, for temporo-maxillary ankylosis, with a successful result.

Murphy[4] in October, 1901, interposed flaps of fascia and muscular tissue from the vastus externus between the patella and femur and tibia and femur for an ankylosed knee, with fair results. He reports 12 cases in all, up to January, 1905, some with remarkable results for the correction of ankylosis of the knee, hip and elbow, which he accomplished by the interposition of flaps with broad pedicles obtained from fascia, fat and muscle adjacent to the ankylosed joint. His paper is most interesting, extensive and valuable.

Hubscher[5] failed to secure permanent freedom of the patella by the use of the interposition of magnesium foil half a centimeter thick.

Berger[6] successfully used the pronator radii teres between the extremities of the bones sutured to the brachialis anticus for elbow ankylosis, and attributes the satisfactory result to the muscular interposition.

Hoffa[7] also successfully used muscle flaps.

Quenu[8] in 1902 interposed soft parts after resection of the elbow for ankylosis. Delbet also praises this method.

Föderl,[9] after experimental ankylosis produced by resection, produced mobility again by the insertion of pieces of bladder or the wall of ovarian cysts.

Baer in 1909[10] reported three cases in which he had used cargile membrane between the separated components of the joints with no resultant motion, and with fever for a few days after the operation. In a fourth case, a knee, in which he used cargile membrane and in which fever occurred, the end result was 10°

[1] 30th Congress of the Deutsche Gesellschaft fur Chir., Berlin, Apr. 13, 1901; Arch. klin Chir., 1901, vol. lxiv, page 696.

[2] Centralb. f. Chir., Sept. 15, 1900; Wein. klin. Woch., 1902–3.

[3] New Orleans Med. Jour., Apr., 1901.

[4] Jour. A. M. A., May 27, 1905, page 1671.

[5] Corresp. blatt f. Schweiz. Aerzte, Dec. 15, 1901, vol. xxxi, page 785.

[6] Bull. et Mem. de la Soc. de Chir., 1903, vol. xxix.

[7] Zeitsch. f. Ortho. Chir., vol. xvii.

[8] Societe de Chirurgie, Paris, June 25, 1902.

[9] Uber Knochen und Knorpelersatz, Wien, klin. Wochenschr., 1902, vol. xvi, pages 1424–1429; Jour. A. M. A., 1905, page 1756.

[10] Amer. Jour. Ortho. Surg., Aug., 1909.

of motion. After the method of Föderl, he then also used bladder from the pig, which he had chromicized, and this he sutured in the newly separated articulation, with the result in the reported cases of 35° motion in a hip, 35° in a knee, 50° in a hip, 75° in a knee and 100° in the upper radio-ulnar articulation. The objection to the method seems to be the postoperative fever, the extrusion of the pieces of bladder through the wound or adjacent tissue at times with resultant sinus formation and suppuration, and in some instances by return of ankylosis, as reported by Osgood[1] and in personal communications of three cases at Saint Agnes' Hospital and Ashbury's observations, as well as the writer's own experience with its use. The advantages claimed by Baer over the bulky muscle flap and fascia method is that the resultant articulation had a much more stable motion and there is a less waddling gait, in other words less bone had to be removed.

Thorn[2] reported a traumatic ankylosis of the elbow in an 11 year old boy. He brought about a mobile joint and then interposed a freely transplanted fascial flap from the thigh. Systematic mechanical treatment, movements and massage were used, and twelve months after the operation the elbow had good movement of 55°. Recently Hauer of Johns Hopkins Hospital had used in an ankylosed elbow a flap from the fascia lata of the patient's thigh with satisfactory results.

Embryology of the Articulations.

The embryology of the articulations is exhaustively covered in Murphy's article, to which those interested may refer, and but one or two points therein need be referred to here.

During foetal development an indifferent connective tissue substance, according to Gegenbauer[3] appears between the ends of the primitive bones and this indifferent tissue soon becomes a cartilaginous plate of mesoblastic origin. This plate in turn splits or liquifies transversely into two cartilaginous plates with an interspace filled with a collagen or gelatin-like substance derived from a splitting of fat capsules, and forms a hygroma-bursa.[4] The interspace goes to form the joint cavity and the collagen the synovia. The cells lining the newly developed cavity appear as flattened endothelial cells; they are really transformed connective tissue cells. In some joints (Gegenbaur), before the split occurs, the bone ends become covered with an articular cartilage and the intermediate substance becomes a continuous inter-articular disc with a special separated joint cavity on each side, or a discontinuous plate, as in the case of the semilunar cartilages, with partially separated joint cavity.

Effect of Muscular Action upon Joints.

Fink[5] considers muscular action all-important in forming the articular ends of bones, which he showed by dividing muscles in dogs and immobilizing the

[1] Boston Med. and Surg. Jour., July 20, 1911.
[2] Zeitschr. f. Chirurgie, Bd. vol. cviii, h. 3–4, page 424.
[3] Zur Morphologie der Gliedmassen der Wirbelthiere, Morphol., 1876, vol. ii.
[4] Langemak, Arch. klin. Chir., vol. lxx, No. 4, page 946.
[5] Ursachen der Knockenformen, 1857.

joints of growing dogs, in each instance changing the shape of the articulation. This would also be in line with the work of Julius Wolff, from whom we have the well-known "Wolff's Law," that "both the internal architecture and external conformation of bones are dependent upon *function* and function alone."[1] This offers an encouraging prospect to us when we have to reshape the components of an ankylosed articulation.

Fink also considers the shape of the articular ends largely due to the degree of activity in the *circulation* of the components, that bone having the nutritional advantage from the blood stream will show hyperplasia or over-growth, and vice versa.

Henke and Reyber[2] maintain that muscular *leverage* contributes largely in determining the shape of the articular ends.

Essentials in Forming a New Joint.

1. All surgeons are agreed that the way ankylosis must be broken up, is either by force or cutting asunder the components of the new joints. We may further conclude from our own experiences, and that of our predecessors, that there must be an *appreciable space between the bones* composing the proposed articulation. Except in those cases in which a simple agglutination has occurred between the synovial surfaces and no pronounced thickening of the synovial membrane or capsule nor any necrosis of cartilage and bone has occurred, in all other cases reunion will unfailingly recur, with simple brisement forcé. In other words, operative failure more often occurs from not removing enough and keeping the raw surfaces apart, until healing occurs, than from the reverse.

2. Everyone familiar with the subject will agree that, after true fibrosis or bony ankylosis is broken up, *something* must be interposed between the opposing denuded surfaces and remain there until such time as the denuded surfaces have healed and will no longer re-adhere or grow together.

3. This "something" must be innocuous; of sufficient thickness and toughness to prevent contact between the opposing surfaces filling every nook and cranny in the denuded part; it must be absorbable, but not absorbable with such rapidity that it disappears from the newly-formed articulation before all granulations have healed. A "something" theoretically, if obtainable, is necessary that can be put into the newly-formed articulation in a liquid form to fill all crevices and that will rapidly congeal and harden, and when in liquid form would be at such a temperature that no scalding of the tissues would occur, and, at the same time, at body heat would not soften sufficiently to spread and allow contact between the bones.

This line of thought was pursued by the writer, when an investigation was begun and he felt that the solution of the problem probably lay, *if fat and fascia be excepted*, in the utilization of the surgical waxes or gelatins combined with fatty substances, to imitate nature with its anyloids, colloids and fats. Some results in research concerning the behavior of the waxes and fats only will be reported.

[1] J. Wolff, Gestz. der Trans., Knochen, Berlin, 1892.
[2] Sitzung der K. K. Wiener Akademie, 1875, vol. lxx.

Substances Employed.

In any substance used for this purpose the beginning of the congealing point must be well below scalding point, 150°F. (65.5°C.) or it must be combined with such other adjuvant substances as to bring the melting and congealing points down, and at the same time not interfere with its ultimate absorbability and innocuousness.

The following substances, with their melting points, were considered and experimented with:

	°C.
White wax	64.65
Yellow wax	62.64
Japan wax	54
Myrica wax	45
Lard	40
Tallow	45
Lanolin	37
Cocoa butter	37

Gelatin begins to congeal at 40°C. and above that point is liquid. Thirty minutes after the withdrawal of this temperature it is hard and solid.

Spermaceti was not considered favorably in the experiments, as it becomes rancid so rapidly and is therefore unsafe. Paraffin, 74° to 76°C., and paraffin mollis, 40 to 42°C., were discarded as insoluble and non-absorbable. Vaselin was also cast aside for the same reason, as an ingredient in any proposed arthritic wax.

Animal Experimentation.

As no substance absorbed in less than four to six weeks would be of value, this point had to be investigated. To determine the rapidity of absorption of any proposed substance, rabbits were used, after the usual antiseptic preparation, and the substance was introduced, under cocaine anaesthesia, through a small incision subcutaneously by means of a glass urethral syringe, as a syringe with a nose was found undesirable from the fact that the wax would cool down too rapidly in passing through the nose of the syringe. The wound was closed with crépe lisse or cotton and collodion.

Rabbit No. 1. Injected subcutaneously with one drachm.

White wax	1	Melting point, 100°F.
Lanolin	40	

Result. Absorbed in 10 days.

Rabbit No. 2. Subcutaneous injection of one drachm.

White wax	1	Melting point, 102°F.
Lanolin	30	

Result. Unabsorbed in two weeks; absorbed in three weeks.

Rabbit No. 3. Injected with same amount as others of

White wax	1	Melting point, 105°F.
Lanolin	15	

Palpable for three weeks.

Rabbit No. 4. Injected with two drachms of

White wax	1	Melting point, 107°F.
Lanolin	10	

Result. Palpable three weeks.

Rabbit No. 5. Similarly treated with

White wax	1	Melting point, 110°F.
Lanolin	6	

Result. Palpable for four weeks.

Rabbit No. 6. The same with

White wax	1	Melting point, 115°F.
Lanolin	3	

Result. Half absorbed in four weeks.

Rabbit No. 7. The same, with

White wax	1.0	Melting point about 125°F.
Lanolin	1.5	

Result. Not entirely absorbed in six weeks.

Similar determinations were made with yellow wax and tallow, and yellow wax, tallow and castor oil, the latter to secure more cohesion and lower melting point. In some mixtures bismuth was added solely for radiographic purposes.

Operation I.—Rabbit No. 9. Under ether and morphia anaesthesia the left front leg was opened with strict asepsis at the elbow, and the entire articulating surfaces were removed from the humerus and ulna down to the bone, so that with fixation and without the interposition of any substance, experimental ankylosis would result under ordinary circumstances. In this instance arthritic wax, composed of yellow wax 1, lanolin 5, was interposed, the capsule and skin were sutured and the wound sealed with collodion. The limb was splinted and strapped to the thorax for two weeks, when it was found the wound had healed *per primam* and there was free motion in the joint. At the present time, three months after the operation, the rabbit has good use of the joint and free movement in it.

Operation II.—B. L., aged 9 years, white, female. Admitted December 1911.

Diagnosis—Infectious atrophic osteo-arthritis ("Rheumatoid Arthritis" or "Still's Disease").

Family history—Father died of pneumonia. Four brothers and sisters died, cause unknown. Mother and five sisters living and well; otherwise negative.

Past History—Has had measles and scarlet fever; no other sickness.

Present illness—Began in 1909, following scarlet fever, with swollen joints which were very painful. No redness, no sweats, slight fever at times. Swelling began in left ankle; later left wrist became involved. Shortly after, patient had swelling in both knees and both elbows, which gradually grew worse.

Physical examination—On patient's admission it was noticed that she was fairly well nourished, but anaemic and hyperaesthetic. Pupils react to both light and accommodation. Mucous membrane fair color. Breath fetid. Two carious teeth and two alveolar abscesses shown in X-ray. Tonsils normal; throat well formed, expansion good. Lungs clear throughout on percussion and auscultation. Heart not enlarged. Slight precordial heaving. No thrill. At apex a blowing systolic murmur is audible, heard over whole heart area. Abdomen: Negative to abnormalities. Extremities: Both knees ankylosed and flexed 30°. Patellae adherent and immobile. Ankles partly ankylosed; very painful on slight manipulation. Little swelling, local temperature not elevated. Hip joints negative. Upper extremities: Shoulder joints negative.

Both elbows nearly completely ankylosed. Left has about 20° of motion and right about 10°. Both wrists slightly swollen and painful on manipulation, as well as the carpo-metacarpal articulations. Slight ankylosis in both regions. Metacarpo-phalangeal joints are involved, as is second joint on middle finger of right hand. Spine is partly ankylosed in cervical and upper dorsal vertebrae. It was determined to try to give mobility to the right knee, as this joint seemed quiescent.

Operative Technique.

After the usual most scrupulous preparation, two incisions were made, one on each side of the patella, about 8 cm. long, extending through the skin, fascia and adipose tissue down to the thickened capsule, the latter being opened, as was also the remains of the synovial membrane, now fibrous tissue. It was found that both surfaces of the membrane adhered and contained no synovial fluid, save a small pocket just above the patella. Bony ankylosis was found between the femur, tibia and patella on each side. By means of an osteotome and periosteal elevator the ankylosis was broken up, after which the necrosed bone was curretted away at the eroded points, and also the diseased cartilage. No attempt was made to remove enough bone and remaining cartilage to permit of normal range of motion. The leg was flexed at an angle of about 45° and the bones pulled apart as far as possible, after which the articulation was filled with a mixture of wax, 1, lanolin, 5, cooled down to about 108°, an abundant supply being put between the patella and femur, after which the joint was held at an angle of 45° until paste hardened, when capsular ligament was sutured with continuous silver wire. The wax mixture having been sterilized in a covered agate jar, was melted and brought to the operating table in a water-bath at the time of injection. A sterile thermometer was put in the wax and a second thermometer in the hot water. Injection was made with an urethral syringe, the temperature being also tested on the operator's arm.

After suturing the skin subcuticularly with silver wire, the wound was covered with silver foil and proper dressings and the leg put up in a plaster of paris cast, at an angle of 45°. This cast was allowed to stay on for one week, then taken off and the leg manipulated under anaesthesia, after which the patient was put up in traction. At the end of the second week, primary healing having occurred, all dressings were removed and extended manipulation attempted, but this was too painful, so at the end of the third week the patient was anaesthetized the second time and knee manipulated, it being found that there were only about 35° of motion, but the patella was freely movable and the limitation of motion between femur and tibia was due to malformation, and transformation of the articular ends of the bones, and not to adhesions.

As this was not satisfactory, except in regard to the patella, and much of the limitation of motion was due to bone malformation, the previously thickened capsular ligament and close apposition of the bones not permitting enough wax to intervene, it was determined to reopen the joint, correct these errors, obtain free movement of the bones upon each other by sufficient excision, and to use a harder wax.

Operation III.—On the same joint, the right knee, an incision was made on inner aspect of the line of the scar of the previous operation, exposing the inner side of joint. The patella was found to be freely movable. On manipulation of the joint a small amount of wax preparation could be squeezed out of the deeper portion of joint cavity. A greater part of the wax preparation that had been injected during the previous operation had been absorbed. Some of the articular cartilage of both femur and tibia had been removed at the previous operation, but these bones were in too close apposition when joint was opened the second time to permit of any marked degree of motion.

There had been apparently some regeneration on the part of the femur; both the external and internal eroded condyles were found to have incapsulated in them the paste mixture which was injected at the previous operation; otherwise there were slight signs of regeneration.

A second incision was made on the inner side of knee, similar to one on outer side, and the entire knee joint exposed, after which a large portion of articular surface of the internal and external condyle was chiseled and curetted away, also a small portion of the articular surface of the tibia, leaving a gap of over 1 cm. on both inner and outer margins of joint. A large part of the capsular ligament was also cut away, but the crucial and lateral ligaments were preserved. The joint cavity was then filled with paste preparation, which filled every part of joint, as it was injected as a liquid. The paste consisted of the following proportions: Yellow wax, 1 part; mutton tallow, 2 parts; castor oil, 2 parts, with 15 grains to the ounce, by weight, of the mixture of bismuth subnitrate. This arthritic wax melts at 140°F. (60°C.) and is semi-solid and begins to congeal at 128° (53°C.). The suspension should be drawn up in the syringe again and again to get a uniform mixture of the bismuth, and for cooling purposes.

The leg was held in full extension with traction while the paste was injected and remained in that position while the paste was hardening, after which the wound was closed with silver wire, etc. The leg was put up in full extension by means of plaster of paris. At the end of 10 days the cast was taken off and the leg manipulated, and it was found to have good motion and no adhesions. The leg was put up in extension by means of traction, a 5 lb. weight being used, and the patient encouraged to move the joint actively several times each day. Three weeks after the second operation the patient has between 40° and 50° of voluntary flexion with little pain, and the remaining motion is simply restricted by voluntary muscular contraction. This range of motion did not increase, however, and two years later, this patient died of endocarditis.

Operation IV.—R. M., aged 17, white girl, admitted January 1912.

Diagnosis. Tuberculosis of the right knee, which is ankylosed firmly in full extension

Family History. Father died of phthisis. Mother living and well. One brother, two sisters, living and well. With exception of father, no other history of tuberculosis. No history of joint or nervous diseases; no malignancy.

Past History. Always healthy, except tumor albus (in 1900). Birth normal. Walked and talked at two years of age. No history of measles, mumps, whoop-

ing-cough or diphtheria. No tonsillitis. Patient is subject to bronchitis. Gastro-intestinal and genito-urinary diseases negative.

Present illness. In 1900 patient had tuberculosis of right knee, which was treated, in the best environment, by bed traction and later by plaster fixation. It became ankylosed. Now no acute symptoms for several years.

Physical Examination.—Well nourished. Skin good color; tongue slightly coated. Lips and mucous membrane good color. No pain on mastoid pressure. No tophi. Eyes react to light and accommodation. Few cervical glands palpable. Thorax well formed. Inspection, palpation, percussion and auscultation show no pathological changes in heart and lungs. Abdomen negative.



FIG. 535.—X-ray of Case IV tuberculous ankylosis right knee before operation.

Extremities normal, with exception of right knee, which is completely ankylosed in extension.

Operation.—A longitudinal incision about 10 cm. in length was made over anterior aspect of right knee, just to outer side of patella, and the joint readily exposed. The prepatella bursa contained a rather large amount of yellowish, caseous material which was curetted out before attempting to open the joint. The joint capsule was definitely thickened and there was a fair amount of granulation tissue about the same. This was cut away, as was the capsule, as far as possible. There are definite bony ankylosis of the joint of a marked eburnated character and this was more marked on the external portions, as pointed out by the preliminary X-ray. The patella was ossified to the femur firmly. The character of the bone in this case was in marked contrast to the preceding case, in which the articular ends of the bones could be easily removed with a curette to the depth of 0.5 cm. It was first freed by osteotomy,

and showed marked pathological changes, having more or less a worm-eaten appearance, and the articular portion was easily ronguered away. An attempt was then made to render the joint movable, which was accomplished by chiseling away the articular portion of the external condyle of the femur and also a large portion of the articular surface of the tibia. At this time the knee could be flexed to almost 90°. After drying the wound thoroughly, the cavity was filled with wax preparation consisting of the following proportions: yellow wax, 1 part; cocoa butter, 2; lanolin, 2; 15 grains of bismuth to the ounce of mixture. Melting point 130°F. The wound was closed with silver wire, silver foil and dry dressings. The leg and foot were put up in a plaster cast in a position of full extension (Figs. 535 and 536).



FIG. 536.—X-ray of Case IV after stereo-arthrolysis. Note wax.

Four days after the operation, the cast was taken off and the leg held in extension by traction, 10 lb. being used. At this time the leg was slightly manipulated and found to be free from adhesions. On the tenth day after the operation the dressings were removed and the wound found to be healed, save a small part of the incision at the lower end where the silver wire suture broke. Leg was manipulated under anaesthesia and no adhesions found. Since then it has not been necessary to give an anaesthetic to manipulate the leg, as *the patient has been daily giving her joint frequent* active and passive movements. On the fifteenth day patient was allowed to walk on leg, she being able to flex the leg on thigh. One month after the operation, the patient had voluntary flexion of about 60°.

The X-rays of these cases show the condition of the joints before and after the introduction of the wax (Figs. 537 and 538).

Three years after this operation, this patient developed pulmonary tuberculosis and died in Eudowood Sanitarium at Towson, Maryland, four years after the operation. Motion, however, persisted in the knee.

Operation V, November 15, 1911.—H. H. H., man, aged 35 years, had traumatic ankylosis of right hip of 11 years' duration. The family history and personal history of this patient were negative in relation to his ailment. The traumatic history was incident to his occupation of consulting electrical engineer, as he had had two injuries to the same hip joint, one dating back 11 years, when a large piece of pipe fell in a building striking him on the right trochanter and producing an impacted fracture and ankylosis for which he was treated in a hospital by traction in abduction for 8 or 10 weeks. The ankylosis hampered him in his work and the affected leg seemed a trifle longer, and led to frequent stubbing of his toe. The second accident happened less than a year before the writer was consulted, and consisted of a fall from a building stage,



FIG. 537.—Case of tuberculous ankylosis of knee after Operation IV. Full extension.

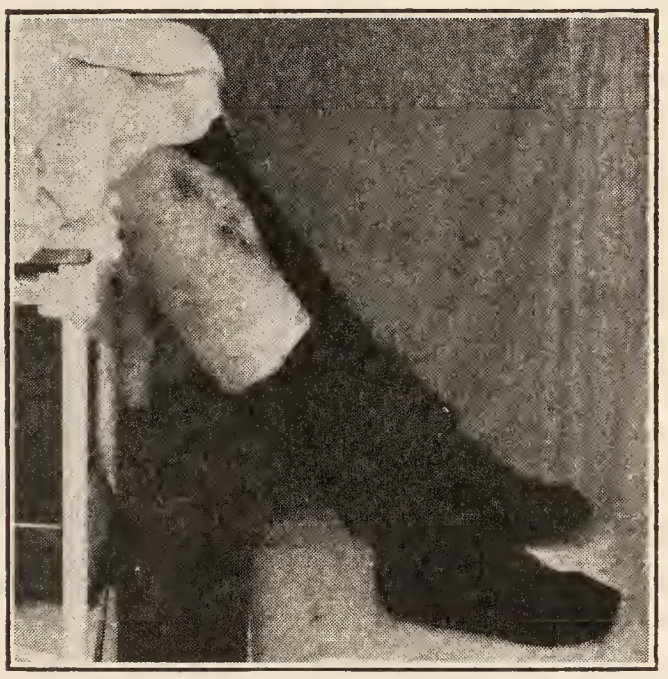


FIG. 538.—Case of tuberculous ankylosis of knee after Operation IV. Sixty degrees voluntary flexion.

of some 15 feet, and striking on his right hip. On admission the leg was in full extension, but adducted 20° and there was an apparent shortening of 4 cm. and no motion in any direction. (The X-ray picture made at this time, shows the adducted position very well, as the trochanter minor is close to the tuberosity of the ischium and the crack in the head of the femur, as a result of the fall, is also shown.) The patient was of a large frame and muscular type, and it was concluded that the anterior incision was preferable. Under ether anaesthesia after a skin incision of 21 cm. extending vertically downward from the anterior superior spine, the tensor vaginae femoris and gluteus medius were retracted outward and the sartorius and biceps retracted inward, and this gave a clear view of the capsule and neck of the femur. With an osteotome and large gouge, after incision of the thickened capsule was made on its anterior aspect, the femoral head was separated from the acetabulum, as close to the latter as possible, and the head rounded. The acetabulum was deepened as much as possible with curettes. Yellow wax, 1, and lanolin, 5, were injected, the capsule was sewed with three interrupted catgut sutures and the skin wound

with continuous subcuticular silver wire. The healing of the wound was uninterrupted. A plaster spica to the toes was used for 10 days and trac-



FIG. 539.—Traumatic osteo-arthritic ankylosis of hip before Operation V.



FIG. 540.—Traumatic osteo-arthritic ankylosis of hip after Operation V.

tion for a month. Three months after the operation the patient had voluntary flexion, 75°; abduction 45°; adduction 30°; outward rotation, 45°; inward rotation 45°. There were no adhesions and no shortening. Figures 539 and 540

show this result well, with the increased distance of the trochanter minor from the ischial tuberosity and the line between the femoral head and neck and new formed acetabulum.

Operation VI.—M. E., girl, aged 14 years, had tuberculous ankylosis of the left hip, of six years' duration. There had been no acute symptoms for three years. Family history was negative with the exception of her father, who had died of pulmonary tuberculosis. Personal history: The patient had had the usual milder exanthemata of childhood and only slight traumatisms which could have been remotely related in a causative capacity with the hip disease. When eight years old the left hip became painful, an abscess developed, and for three years the patient was off and on in various hospitals and summer homes



FIG. 541.—X-ray of ankylosed tuberculous hip before Operation VI.

for treatment, which consisted of bed traction, the use of traction splints and spicas. The patient on admission was a tall, thin girl with fair color, showing an extreme limp from the ankylosis of the left hip in a malposition. There was an apparent shortening of 12 cm. and the thigh was held in 30° of flexion and 20° of adduction. No motion in any direction. Under ether anaesthesia (February 19, 1912) the posterolateral incision was used, the curved lateral incision extending through the skin about 21 cm. from the anterior superior spine to the trochanter and then down the shaft of the bone and at its midpoint a posterior incision about 10 cm. directly backward. Some fibres of the gluteus medius were cut and the other muscles, being retracted forward, gave a good view of the femoral neck and the remains of the head. With osteotome and gouge the ankylosis was cut through and head and acetabulum shaped, after which yellow wax, 1 and lanolin, 5, were injected at about 125°F. After

the deformity was overcome, the leg—as in Operation V was put straight in a plaster of paris spica at first and traction used later. The healing was uninterrupted and the result, five months after the operation, was: Right leg, 84 cm.;

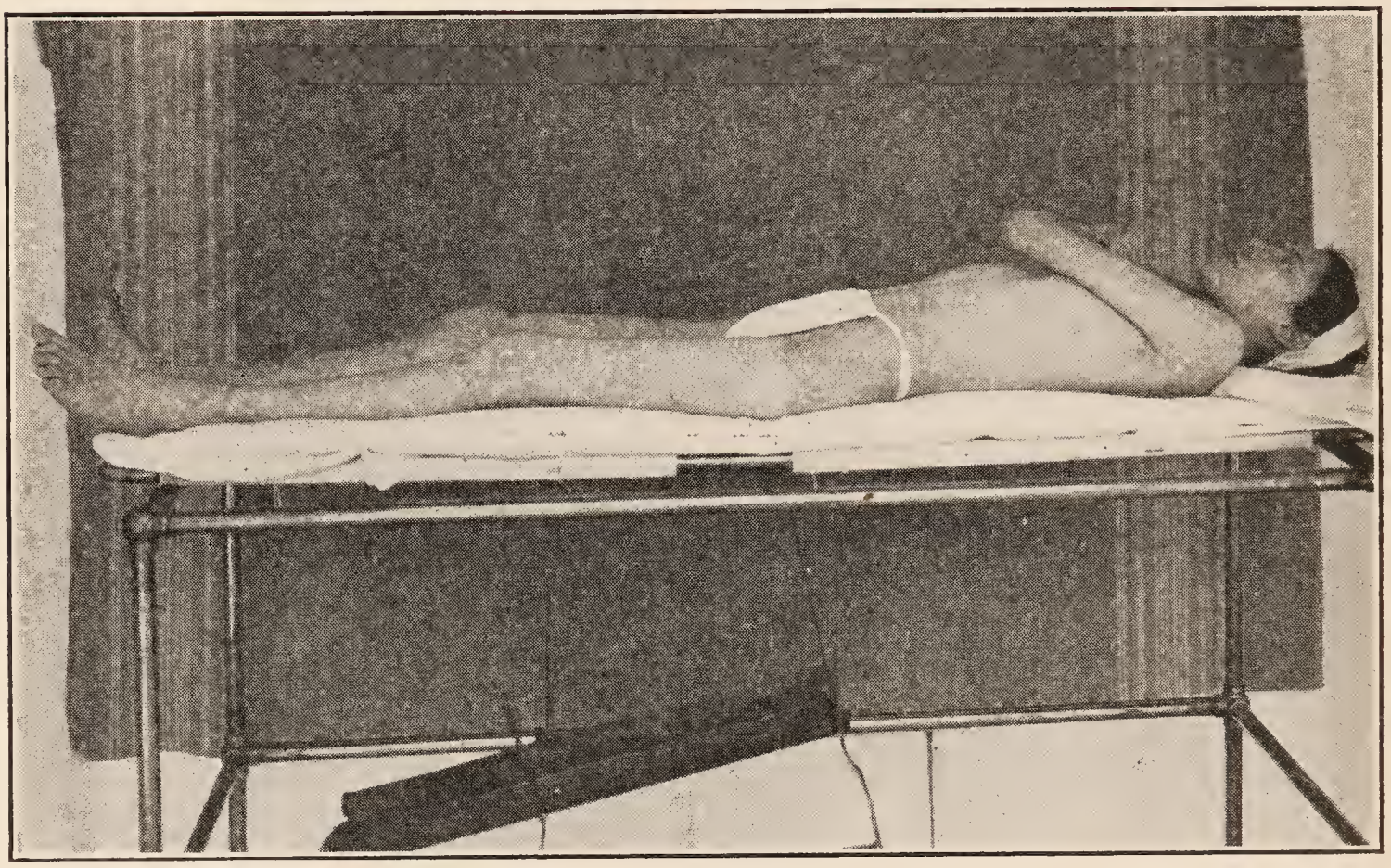


FIG. 542.—Patient after Operation VI showing full extension of thigh.

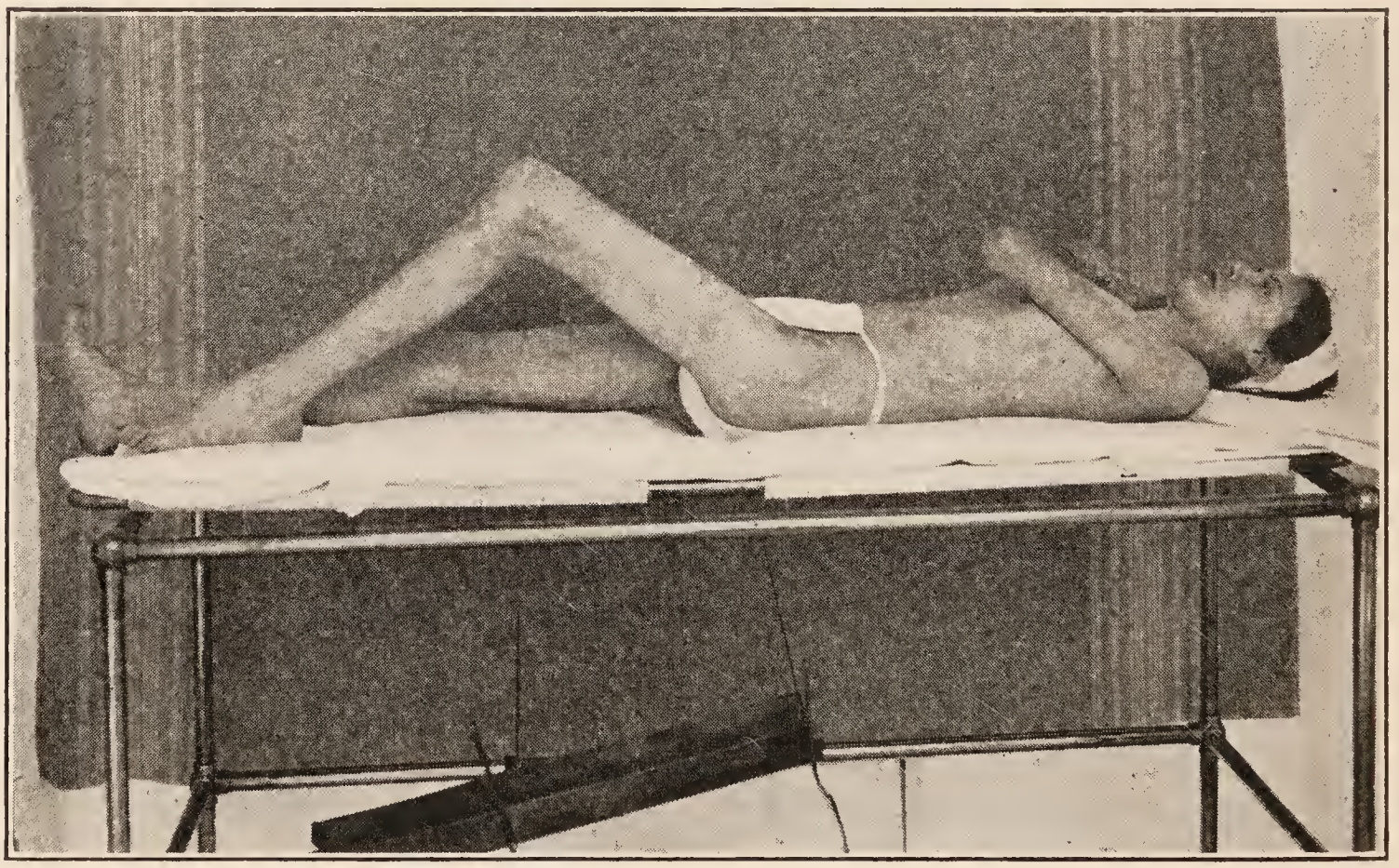


FIG. 543.—Patient after Operation VI showing voluntary flexion of 45 degrees.

left leg, 83 cm.; motion in voluntary flexion, 45°; rotation in and out, 25°; no adhesions can be made out and the malpositions in flexon and adduction are overcome (Figs. 541, 542 and 543).

This operation was undertaken in this case in preference to the usual Gant's subtrochanteric osteotomy for the relief of the deformity and shortening with the hope of helping the motion somewhat, also.

Operation VII.—E. S., boy, aged six years, had on admission firm ankylosis of the right hip, following tuberculosis. The disease dated back three years and there had been no acute symptoms for one year. The thigh was held at 90° with the body and there was no motion, and extreme limp forced the patient to stoop forward until the body was parallel with the floor at each step attempted with the right leg. There was some 45° also of fixed abduction.

The family and personal history had little bearing on the case. The child had been treated elsewhere by spicas in abduction. February 19, 1912, a posterolateral incision was employed and this patient was treated as the one in Operation VI, with the exception that no amount of bone that could be avoided was removed from the femoral head for fear of interfering further with the epiphyseal growth. The arthrolytic wax was used as in the last case and the same aftertreatment employed. The abduction and 60° of the flexion was overcome and this correction persisted. Six months after the operation there was 20° of motion in flexion with no reformation of adhesions.

Operation VIII.—This was undertaken February 7, 1912, on a man, W. K., aged 19 years, who had had a tuberculous ankylosis of the right knee in full extension for six years, the knee trouble dating back 10 years, only in the first four of which did he have acute symptoms. His mother died of phthisis, otherwise his family and personal history was negative. He was a well nourished young man with good color. His knee, prior to admission for the restoration of mobility, had been treated in years gone by, by traction and fixation in plaster casts and also by an erasion, the scars of which operation were visible on each side of the patella, as were buried silver sutures in the capsule. Under ether the old incisions were opened and much fibrous tissue was found which was dissected away with the exception of the lateral ligaments. The patella was chiseled free and the tibia and femur were cut apart. Owing to the change in shape from flattening of the ends of these large bones, it was not possible, without extensive articular destruction, to get more than 30° of motion at the time of the operation and from fear of rekindling the tuberculous process. The wax lanolin mixture, 1 to 5, was used and three months after the patient had 20° of flexion and no recurrence of ankylosis between the patella and femur or femur and tibia, but *with some leakage of wax* through the inner incision which continued to leak for a year or more.

Operation IX.—M. K., girl, aged 18 years, had had tuberculous ankylosis of right hip, of eight years' duration. Her hip trouble was thought by her family to have followed antitoxin injection for an attack of diphtheria, as a child. Her family and personal history was negative otherwise, and her physical examination showed an apparently normal girl other than the affected hip.

On admission, the position of flexion of the right hip was 60°; right leg was 87.5 cm. and left leg 93 cm. Apparent length measured from the umbilicus, right leg 96 cm. and left leg 104 cm. Distance between anterior spines 27 cm. Right leg apparently adducted 30°. Right trochanter 4.5 cm. above Nelaton's Line.

November 4, 1912, under ether, an incision was made 4 cm. posterior to the anterior superior spine, extending in a curve down the thigh, convex posteriorly, for a distance of 15 cm. and extending through the adipose tissue to the gluteal muscles. A posterior incision was made from the mid-point of the lateral incision, extending downward and backward 5 cm., exposing the gluteal muscles. The fibres of the gluteus maximus and medius were separated, exposing the great trochanter. The top of this bone was chiseled off, exposing the neck of the femur. About one-fourth of the head of the femur was resected, removing with a curette a considerable amount of osteoporotic bone. After this the acetabulum was smoothed with a curette. This allowed free motion of the ankylosed joint in all directions. The cavity was swabbed out dry and a mixture of paste, containing lanolin, 3 parts, and beeswax, 1 part, was injected. The capsule was closed with silk sutures. The great trochanter was fastened in place with silver wire. The usual dressing wax applied, and the patient returned from the operating room in good condition.

Four months after, position of flexion was 0°; position of adduction, 10°; motion, 60° in flexion. There was *some leakage of wax*, which was too hard.

Conclusions.

As seen from a detailed account of these cases in which it was used, we find, if very extensive bone resection is done, lateral instability results and if sufficient bone is not removed, reankylosis occurs, so that surgical judgment of the first order and extensive experience is required. Muscle spasm may be a trouble-some symptom from instability and slipping after extensive resection at the hip. The introduction of foreign substance, non-absorbable as well as absorbable, leads sooner or later to *its extrusion through the wound.* The analogy to autogenous bone-grafts holds here, and in the long run, it will be found that the use of fat and fascia from the patient with or without pedicle will yield better results than any other means, when the joint has been remodeled skillfully and sufficient space is left between the components. Early active movement by the patient is one of the most important elements in the after-treatment. No opinion can be expressed shortly after any arthrolytic operation, as to the end result and at least six months must elapse before the real value of any given procedure can be estimated. Each case is a law unto itself, owing to varying conditions, individual pecularities of resistance or repair, extent of involvement and coöperation in after-treatment.

For details of arthrolysis by fat, fascia and muscle interposed on different joints, the reader is referred to articles on this subject by Albee (Orthopaedic and Reconstruction Surgery, S. B. Saunders and Company, 1919), MacAusland (Journal A. M. A. January, 1915, lxiv, page 312), Murphy (Journal A. M. A. June 30th, 1905), and Allison and Brooks[1] for a general conclusion on the various problems of mobilization.

Arthrodesis.

Certain conditions of joint irritation such as the extension of tuberculous disease in adults or in cases of joint instability or to promote function following

[1] Allison and Brooks, Surgery, Gyn. and Obst., Nov., 1914, pages 568–581.

paralytic loss of muscle balance, require the production of union or arthrodesis between adjacent bones.

Arthrodesis in Tubercular Joint Disease.

This procedure which is best accomplished by partial excision or erasion supplimented by a bone-graft should not be employed for children for fear of stopping further growth of the limb from interference with or partial removal of adjacent epiphyses. On the other hand, in adults the surgical production of arthrodesis is indicated if the conservative methods of traction and fixation fail to arrest the acute symptoms or for reasons demanding a shortening of the invalidism, or in convalescence there remain only 5° to 10° of motion, which amount may be a detriment compared with the solidity afforded by ankylosis.

The author is opposed to the indiscriminate production of arthrodesis or employing any method of treatment in tuberculous joints (if we may except the spine), which lead to the rapid production of ankylosis. Such methods as spicas in hip disease and weight-bearing as advocated by Lorenz and others tend to do this. What is primarily to be desired under ordinary conditions in Tuberculous Joint Disease is the maintenance of the maximum amount of function possible. The judgment of the surgeon, however, must govern in the case, that is not doing well in the ordinary routine of treatment or in the partially ankylosed and lead him to resort to arthrodesis.

Albee has suggested many ingenious methods by bone-graft of accomplishing this. In the hip he takes a bone-graft from the tibia (the graft should be taken before opening a tuberculous area manifestly for aseptic reasons), splits it and inserts these two parts in two sockets prepared with an osteotome on the side of the ilium above and posterior to the acetabulum, these grafts then converging to a split in the trochanter major, where they are sutured with kangaroo tendon.

In the knee, after a graft is obtained of some four or five inches long from the tibia and placed in normal salt solution, the joint is widely opened and all the tubercular and granulation tissue removed, a bed is made in the antero-medial aspects of the femoral and tibial condyles for its reception and it is sutured there with kangaroo tendon.

The wrist and ankle may similarly be immobilized and splinted by bone-inlay or bone pegs driven into the healthy substance of the bones adjacent to the articulation.

Arthrodesis after Infantile Paralysis as pointed out by Davis, Naughton Dunn of England,[1] Steindler, Gill[2] and others accomplished by partial resection, curetting, gouging or chiseling in the subastragaloid, the calcaneo-cubiod or astragalo-scaphoid regions are the best methods of promoting stability and ankylosis with restoration of normal foot balance and weight-bearing. Others have recommended bone pegs driven through the adjacent bones to accomplish the same end. These procedures are especially indicated in flail or "dangle foot," loss of balance with bone change resulting in serious pronation or supina-

[1] Stabilizing Operations in the Treatment of Paralytic Deformities of the Foot, John Wright and Sons, Ltd., Bristol, 1922.

[2] Jour. Amer. Ortho. Assoc., 1921.

tion, calcaneo-cavus and like conditions where no available living tendons are at hand for transplantation. These methods may be spoken of as "Tarsal Remodeling" and Arthrodesis. It is useful to produce "Back-knee" and Equinus.

One of the most valuable arthrodeses is that obtained in the shoulder in children over eight years old in that condition following Anterior Poliomyelitis. The Deltoid is entirely paralyzed and thereby the patient loses all power of abduction, flexion and extension of the arm. In these cases the trapezius, rhomboids and other scapular muscles are intact and arthrodesis between the humeral head and glenoid cavity will afford a restoration of these lost motions by moving the scapula. After the capsule is opened through an antero-lateral incision, the synovial membrane and cartilage removed and the opposing bone surfaces denuded, with or without nailing with a bonepeg through the humeral head, glenoid or acromion process, the arm being held nearly at 90° of abduction, 60° of flexion and inward rotation of 90°, a body and arm cast is applied, which is to be worn 8 to 12 weeks, when union, in a properly performed procedure, will be found solid and nearly all necessary functions are possible. From the contraction of the pectoralis major and subscapularis, tenotomy of these tendons near the bicipital groove is sometimes necessary to overcome the inward rotation, as in Obstetrical Paralysis.

No bony ankylosing operation should be attempted on children under eight, as one would be doomed to disappointment from the preponderance of a cartilagenous condition in the bones and no arthrodesis would result.

CHAPTER XXVI

RECONSTRUCTION OF THE HAND[1]

A New Technique in Tenoplasty.

In the treatment of traumatisms and infections which impair function, from an industrial and wage earning standpoint, it will be granted that the hand comes next in importance to the brain and eye (Fig. 544). It was with this thought in mind that the present investigation and research were instituted in an endeavor to better, if possible, the technique involved in the restoration of the function of



FIG. 544.—Both hands rendered useless by destruction of carpus, ankylosis, and binding down of tendons in scar tissue.

the hand. Such restoration includes, of course, lesions of the fingers, hand, wrist, and forearm, and involves changes in the skin, fascia, palmar spaces, bursae, nerves, bones, articulations, ligaments, muscles, or tendons or all of these.

The chief factors which produce impairment of function in the hand are infections, penetrating wounds, and deep burns. To this list must be added



FIG. 545.—Contracture of finger following "traumatic surgery," which resulted in adhesion in tendon sheath.

operative traumatism, as every surgeon of experience has encountered cases in which the most scrupulous and apparently aseptic technique has been observed and primary healing has followed, but as an end-result, adhesions have formed or contractures occurred from operative traumatism, which vitiated perfect restoration (Fig. 545).

[1] R. T. Taylor, Surg., Gynec. and Obst., Mar., 1921, pages 237–248.

It is not possible to cover the detailed treatment of each of these disabilities, except by a brief reference to the mode of procedure employed in certain cited cases. Chief attention will be paid to lost function in the tendons.

Even from the standpoint of restoration of function in the tendons, much depends upon the previously correct diagnosis of the original lesion and initial treatment or maltreatment. Many seriously deformed hands from lacerations and infections are the result of needless incisions in the wrong place or dilatory incisions in the right place. In some of such cases, perfect functional restoration is next to impossible. It, therefore, follows that much restoration later may be avoided, if the original treatment is on scientific lines. A correct knowledge of proper early treatment of the various affections and injuries to this member



FIG. 546.—Sites for incision on dorsum. (*Kanavel.*)



FIG. 547.—Sites for incision on palmar surface. (*Kanavel.*)

is pointed out in Kanavel's *Infections of the Hand*, that valuable and useful book to all who are called on to do accident surgery of the upper extremity. Thus a hand or forearm presenting a lymphangitis must be treated entirely differently from a tenosynovitis and so must fascial space and bursal infection. As Kanavel says:

"The location of the greatest swelling comes in those areas where there is the largest amount of loose cellular tissue, i.e., upon the dorsum, while in 9 cases out of 10 the pus is on the flexor surface.

"The site of the greatest tenderness is of marked importance in the location of the pus.

"The treatment of the three types is essentially different and the gravest error will be made, if they are not differentiated, since their treatment is diametrically opposed" (Figs. 546 and 547).

Briefly stated:

(*a*) Lymphangitis shows little locally except at the site of the invasion and streaks along the lymphatics on the *dorsum* of the hand and forearm, but, is manifested chiefly systemically by the fever and malaise of infection. Indiscrimate incision in such cases is not only not indicated, but positively harmful. Hot dressings, preferably saturated with boric solution, rest of the part locally, and systematic elimination must be relied on chiefly, until the acute symptoms subside.

(*b*) Tenosynovitis is shown by exquisite tenderness over the *course* of the sheath and limited to the sheath and increased pain on extension, especially proximally. In such cases under *general anaesthesia*, preferably nitrous oxide and oxygen, and *in a bloodless field* the tendon sheaths should be freely opened *laterally, not centrally*, with care to preserve so far as possible the fascial sheaths that act as pulleys at the flexures of the fingers, and should be dressed with vaseline gauze.



FIG. 548.—Synovial sheaths of palmar surface and wrist. (*Poirier and Charpy.*)



FIG. 549.—Same.



FIG. 550.—Same.

(*c*) Palmar, thenal, and hypothenal space infections and radial and ulnar bursal involvement, often secondary to neglected tenosynovitis, should be carefully differentiated and freely incised in the proper location to secure maximum drainage and avoid vessels and nerves. Kanavel recommends the continuance of the bloodless bandage after operation, sufficiently tight to produce passive congestion for 24 hours, and thus allow slow absorption of toxins (Figs. 548, 549 and 550).

Too great conservatism is as dangerous in early treatment as radical indiscriminate surgery, for the reason that in the former, undue delay permits extension of the infection from one region to the other, as the latter may cause unnecessary infection and destruction of tissue or function in opening up uninvolved areas. A good rule is to be sure of the chief and primary location of pus, incise and follow up its extension to other spaces and bursae by additional incisions to secure free drainage, if necessary (Figs. 551 and 552).

As pointed out by Willmes, early passive and active use will help to force pus out of adequate incisions and promote return of function. The surgeon with gloved hand may accomplish this manipulation with less pain to the patient, if the latter's hand is immersed in hot water (Figs. 553 and 554).



FIG. 551.—Synovial sheaths on back of hand. (*Poirer and Charpy.*)

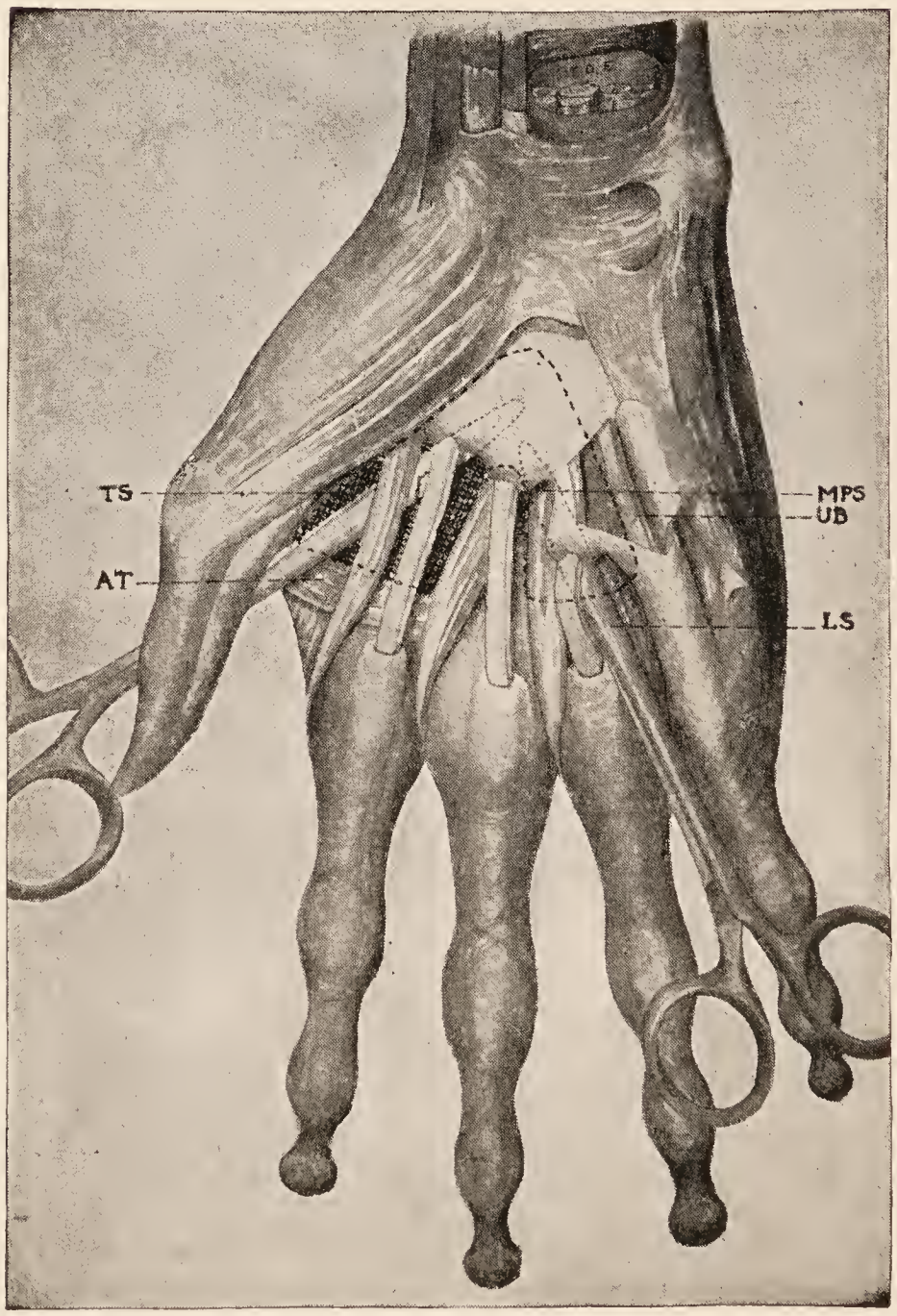


FIG. 552.—Drainage of mid-palmar space. (*Kanavel.*)

Unfortunately, many cases presenting themselves to the reconstructing surgeon are samples of previously bad jobs with not only ruthless disregard to ultimate function, but evidence of ignorance of anatomical pathology.

In addition to this, some reconstruction with an aim at functional restoration is marred by what may be termed traumatic surgery or what has been previously spoken of as "operative traumatism." By this is meant the unnecessary wounding of tendon structures during operation, drying out, having the skin incision directly over the line of repair of a tendon-sheath or tendon, leading to adhesions and contractures, so as to vitiate *partially or wholly* the entire operative procedure, just as surely as a break in an aseptic technique with infection would.

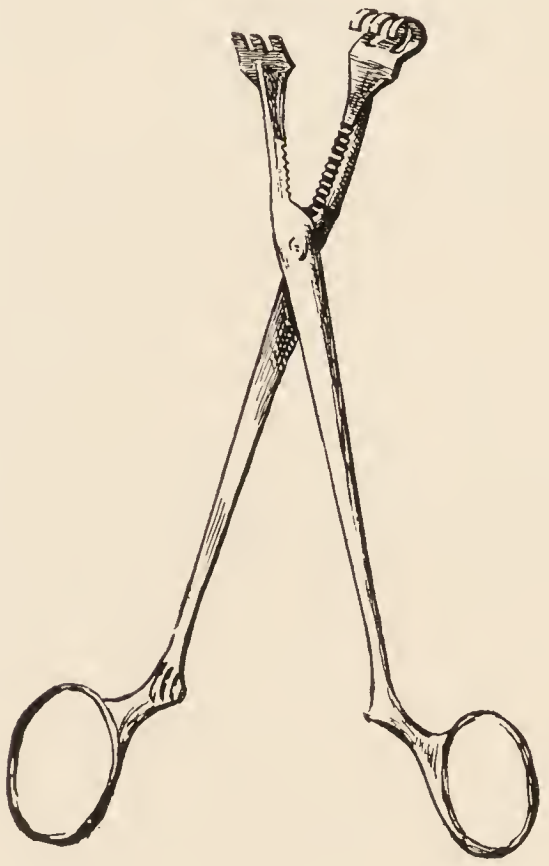


FIG. 553.—The second instrument devised as a tendon clamp, by the author.

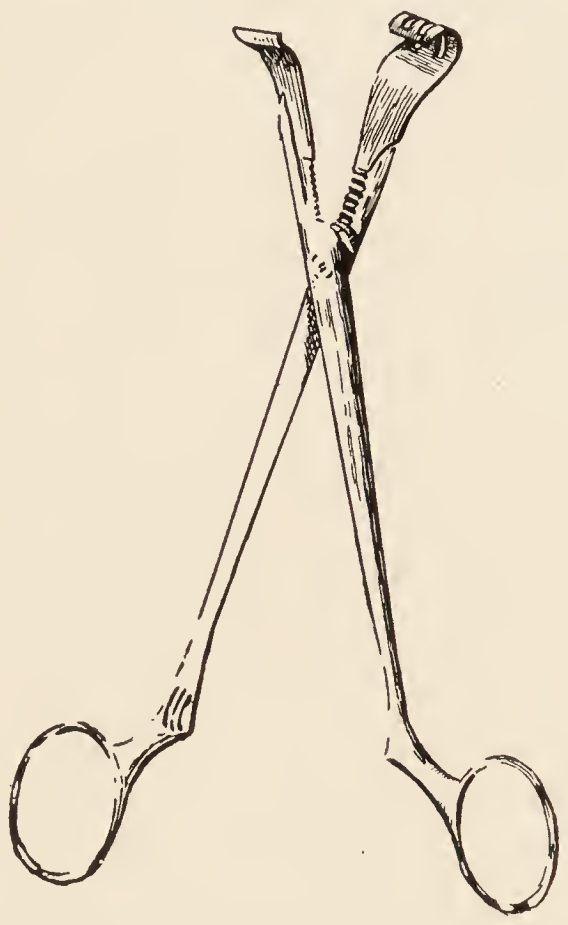


FIG. 554.—The third type of tendon clamp devised.

Preparation for Tendon Operations on the Hand.

The writer has had more perfect results in tenoplasty by resorting to the old method of skin sterilization rather than by the popular and generally used iodine and alcohol method.

The older method referred to is the preparation 24 hours in advance of the operation, i.e.: (1) green soap scrub and shave; (2) application in turn of (*a*) permanganate of potassium solution (3 : 100), (*b*) oxalic acid solution (3 : 100), (*c*) ether, (*d*) alcohol, (*e*) bichloride of mercury (1 : 5000) solution, applied on wet towels from finger tips to axilla until patient is etherized and operator is ready to begin.

Bloodless Field.

It is hardly necessary to mention that this work should be done in a bloodless field to secure clear recognition of the parts and to avoid the necessity of sponging, which, if required, should be done with *moist absorbent cotton* and *not wiped with gauze*. After applying the rubber bandage with uniform firm pressure from the hand to the elbow, the round U. S. Army constrictor should be applied

by four turns, making a wide band above the internal condyle of the humerus which region is covered by a gauze handkerchief to protect the ulnar nerve. With this technique, danger of pressure paralysis is remote and almost negligible.

Skin incision should not be over the point of the desired tendinous union. As previously stated, a crescentic or semi-circular flap should be dissected back at the beginning of the operation, so that the point of tendinous union should not lie under the line of suture of the skin for fear of being caught in the skin scar and interfering with ultimate function.

Protection of Field of Work from Drying during Exposure.

Soon after the tendons in question are exposed, bits of absorbent cotton wet in a bowl of normal salt solution should cover the field of work as far as possible to keep the tissues moist.

Sterling Bunnell,[1] of San Francisco, applied the term "atraumatic technique" to tenoplasty in sewing tendons end-to-end and devised an instrument of thin metal which might be wrapped around the tendon's end to facilitate handling and not traumatize, as rat-tooth or mouse-tooth forceps or even a haemostat would, if the tendon during the operative procedure was held by it. Bunnell's tendon clamp consists of two parts and really three procedures are involved in its application. One piece, a strip containing two fenestra in the centre, first is folded over the tendon and held in place; second, a slide of the same metal like the sliding keeper of a belt to hold the tendon securely in the strip, is put on. The slide is then held in place by a haemostat as the third procedure. It has seemed to the writer that in a large number of cases these three procedures would be greatly facilitated by the use of one instrument fenestrated for suturing and for grasping without traumatism, and entail the possibly unsurgical manual handling of the tendon, which procedure is especially dainty, tedious, and time-consuming in applying the minute slide over the two ends of the tendon-holding strip of thin metal now doubled over the tendon.

The New Instruments.

Accordingly, the writer had pieces of equal size of thin, flat German silver soldered on the ends of minute mosquito haemostats and curved in varying degrees to grasp tendons of varying sizes, and dentated so that when closed centrally the intervals between the dentates would become fenestra through which sutures could be passed. These instruments after repeated use demonstrated that the very thin metal would bend and prevent close central approximation of the dentates and would cause the suture material, fine intestinal silk, to catch on the projecting dentates.

The next instrument devised was a dentated crook-like piece made of steel attached to one blade of the mosquito clamp with a trident on the other to coapt laterally and not centrally. Sutures were more readily applied with this, but still, silk occasionally caught and retarded the operative procedure (Fig. 553).

Next, a similar crook-like instrument was made with fenestra, but with a straight edge of contact with the smaller blade and no dentations. It was found the crook-like portion could be instantly put around the tendon just as a blunt

[1] Surg., Gynec. and Obst., 1918, vol. xxviii, pages 103–110.

retractor is placed in tissues, the instrument closed, and the slippery tendon then held firmly while the sutures were inserted (Fig. 554). This instrument was most satisfactory, but with a desire to have as small an instrument as possible, especially such as is sometimes required in the palm of a flexed hand, the haemostat type was discarded for the final type shown (Fig. 555), made of clock spring

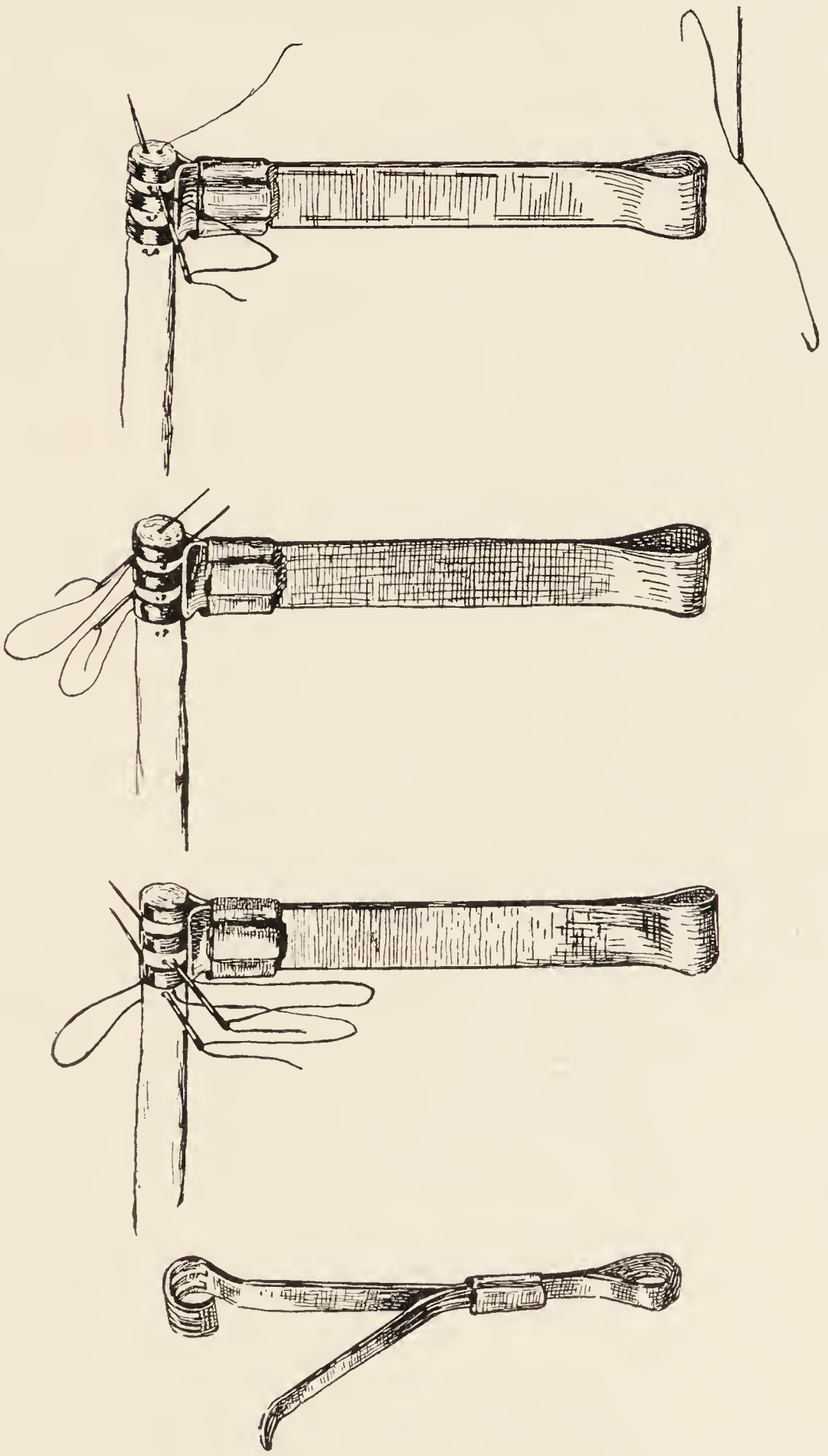


Fig. 555.—The author's accepted type of clamp made of clock spring.
Fig. 556.—Silk threaded in two needles showing transfixtion of tendon to left of clamp. After the thread is passed obliquely on its return from the far side back to the near side in the first fenestrum, it is passed obliquely to the far side in the second fenestrum. (The writer's technique.)
Fig. 557.—Needle passing from the far side of the second fenestrum to the end of the tendon.
Fig. 558.—The second needle passing from the near side of the second fenestrum through the end of the tendon.

with a slide lock but with the same fenestrated blunt retractor-like end. This has been entirely satisfactory.

The writer has found three sets, of two each of these, useful for tendons of the hand, varying in sizes of two, four, or six millimeters in diameter. The retractor-like blade is 10 millimeters wide and the fenestra are 2 millimeters wide

to allow the easy, oblique passage of a straight cambric needle. The whole instrument is about 10 centimeters long.

New Technique in Applying Sutures.

With the new instrument it was found possible to work out a *new technique* whereby a more perfect application of the fine silk approximation of stay sutures might be put in, leaving a *minimum of silk exposed* to prevent the production of possible *traumatic adhesion* from the silk.

This method consists of threading a fine straight cambric needle on each end of fine intestinal silk of suitable length. With the tendon clamp applied as close to the end of the cleanly severed end of the tendon as possible, the first needle transfixes the tendon just beyond the clamp straight through and it immediately transfixes the tendon obliquely, coming out of the first fenestrum on the *near side;* then it immediately transfixes the tendon obliquely coming out the second fenestrum of the *far side*, and finally transfixes the tendon obliquely, coming out

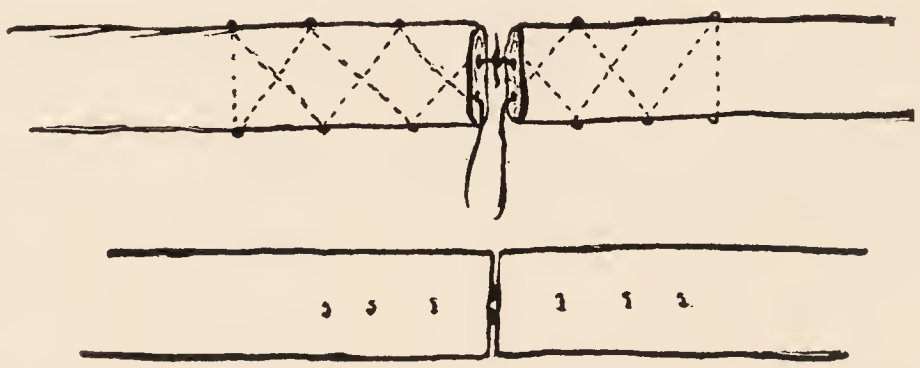


FIG. 559.—Above, diagram shows the course of the silk through the tendons and end-to-end tying. Below, lateral view of end-to-end approximation of tendons. Dots of silk are the only evidence of this method of suturing.

the free end of the tendon, when the first needle is removed. Now, with the second needle the same sort of procedure is carried out, only in the reverse direction, coming out obliquely in the first fenestrum on the *far side*, then the second on the *near side*, and, finally, the opposite side of the free end of the tendon (Figs. 556, 557 and 558). Thus it will be seen that there remains none of the silk exposed on the side of the tendon, except small dots. When a similar arrangement of sutures is placed in the other tendon, the four silk strands may be tied closely, approximating the severed ends end-to-end by double surgeon's knots and the excess of silk cut away, so that these knots are entirely buried between the cut ends of the tendons (Fig. 559).

Protection of Point of Union by Fat.

Small sheets of fascia and fat should be dissected from the subcutaneous tissues adjacent and wrapped around the point of union in order to prevent adhesion, so far as possible.

Figures 560 and 561 show the application of the new tendon clamps in operative tendon transplantation of the flexor sublimis digitorum from the middle finger to the flexor profundus digitorum of the index finger. The crescentic flap is shown as is also the moist cotton to prevent drying during the operative technique and the application and tying of sutures.

Review of Tendinous Arrangement in the Hand.

It will be recalled that on the palmar aspect each finger has two flexor tendons, a superficial and a deep. Of these, the superficial is chiefly concerned in flexing the first phalanx at the metacarpophalangeal joint on the corresponding metacarpal bone, while the deep flexor has for its chief function not only the flexion of the first phalanx on the corresponding metacarpal bone, but the phalanges on each other. Therefore, if we are to depend on one only, the deep flexor alone will give us more function than the superficial flexor alone and if in the palm of the hand both flexors have been severed or bound down in scar tissue, we will naturally attach a transplanted tendon to the distal end of the remaining stump of the injured profundus. Further, in choosing a tendon to transplant and take the

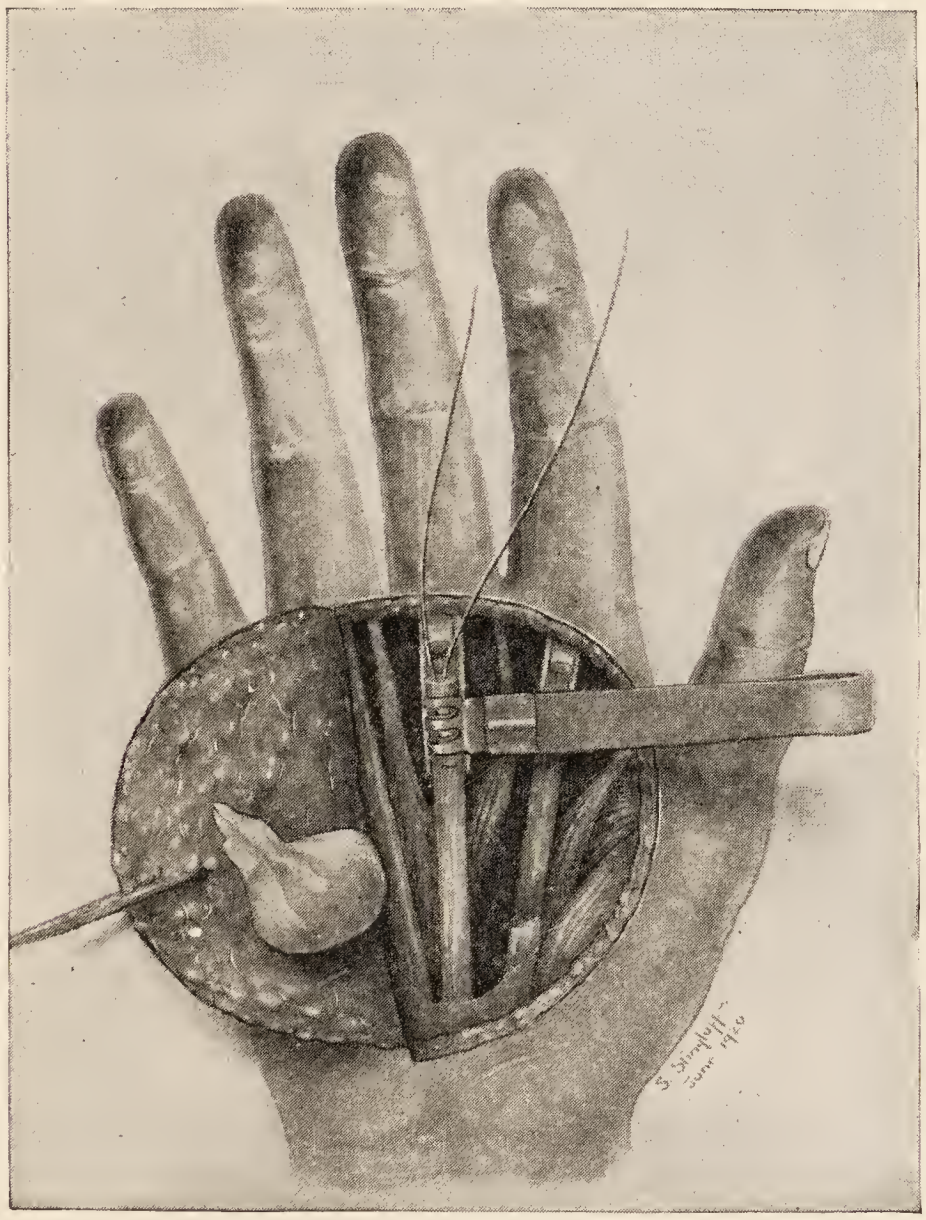


FIG. 560.—Tendon clamp applied to the sublimis of the third finger of the right hand. Suture *in situ* and ready for transplantation. On the left is shown the wet pledget of cotton, which, in practice, is spread over the tendons except at the point where work is actually being done, to prevent drying out of the tendons. The sheath of the sublimis is shown attached to distal end of severed tendon. (See Case 3.)

place of the one destroyed, we will naturally select or steal the sublimis, as we will thereby interfere to a less degree with the remaining function of the finger from which the theft is made, than if we had stolen the profundus. Figure 562 shows the sublimis tendons cut away proximally and distally in the palm to expose the underlying profundus tendons.

Passing now to the dorsal aspect, we find the thumb, index, and little fingers supplied with more than one extensor tendon, so that with care in selection to

accomplish greater efficiency in general manual function, a tendon from one of these may be stolen (Fig. 563).

It will be found also in making a transplantation from the palmar surface to the dorsum for paralysis or other loss of extensor function, it is better to make the transplantation to one tendon, rather than suture to a group, for the reason that the application of force in one direction will yield greater precision, than if it is split up in several directions. For example, suture to all the extensor tendons of the fingers, is not as satisfactory as suture to the extensor of the middle finger for simple wrist drop. If, however, the wrist drop occurs chiefly to the ulnar side from underaction of the extensor carpi radialis longior, it would

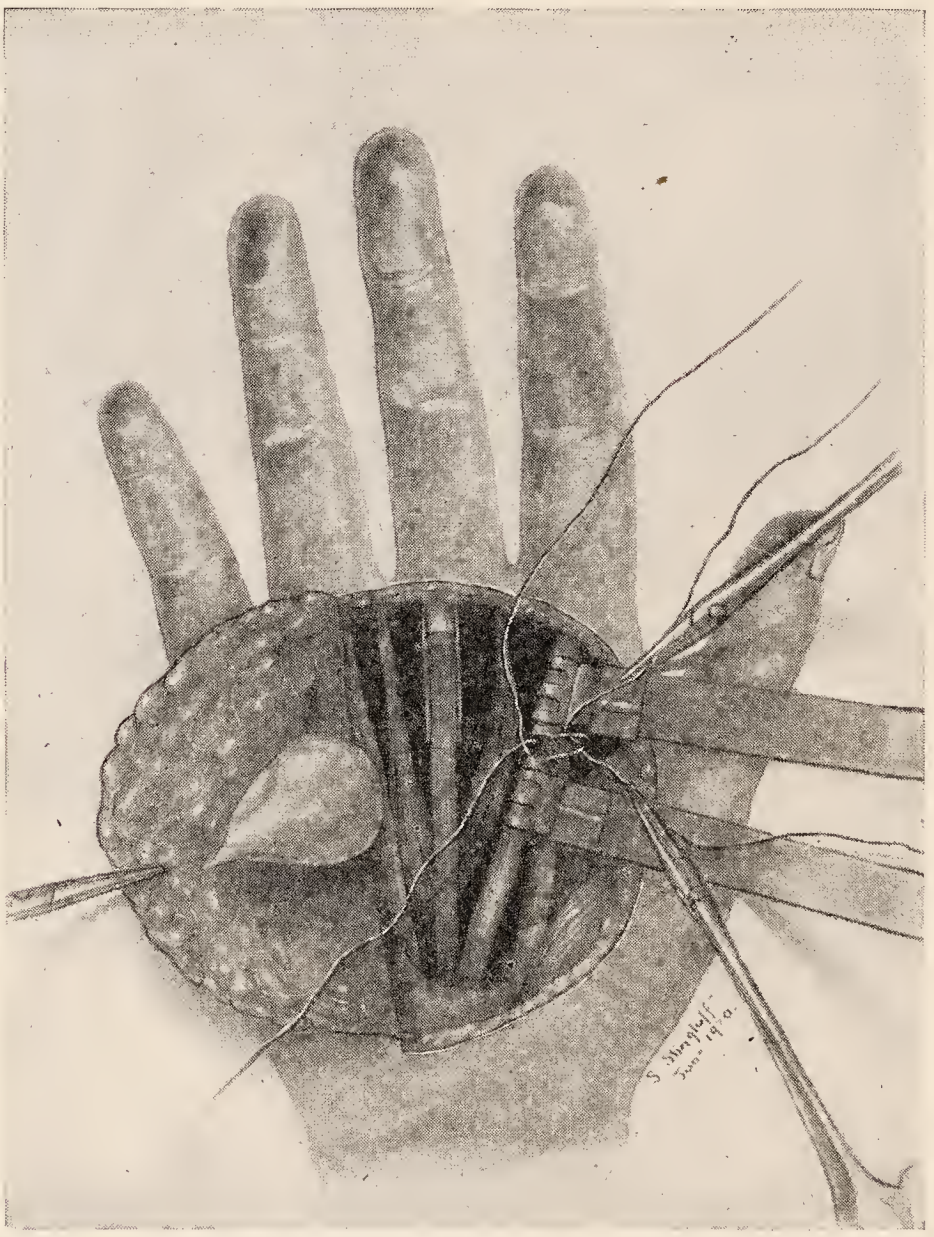


FIG. 561,—The proximal end of the sublimis tendon with suture *in situ* is here shown approximated as instrumental knotting of the silk sutures is effected. As in Fig. 560 the wet cotton is here also gathered in a mass as otherwise it would obscure the relationship of the parts.

be more efficient and more correct mechanically to make our transplant to one of the extensors of the index finger or the thumb, etc. or to the dorsal periosteum.

Further, in the experience of the writer, it is necessary to attach our tendons *under* tension, to allow for stretching, to hold the part in rather *extreme overcorrection* when sutured, whether our transplant is attached to bone, periosteum or tendon to tendon, but Mayer[1] and some others dissent from this view and hold that the natural tonicity of the muscles will provide for this. When, however, we consider possible changes in the articulations and bones according to Wolff's law in deformity, another justification is found for overcorrection

[1] Biesalski and Mayer, Die physiologische Sehnenverpflanzung, Berlin, 1916.

entirely to correct deformity, as frequently in deformities we are not dealing with soft parts alone, but bones as well.

Application.

CASE 1. A strong, vigorous girl otherwise, had had frequent recurrent attacks of backward dislocation of the right thumb at the metacarpophalangeal

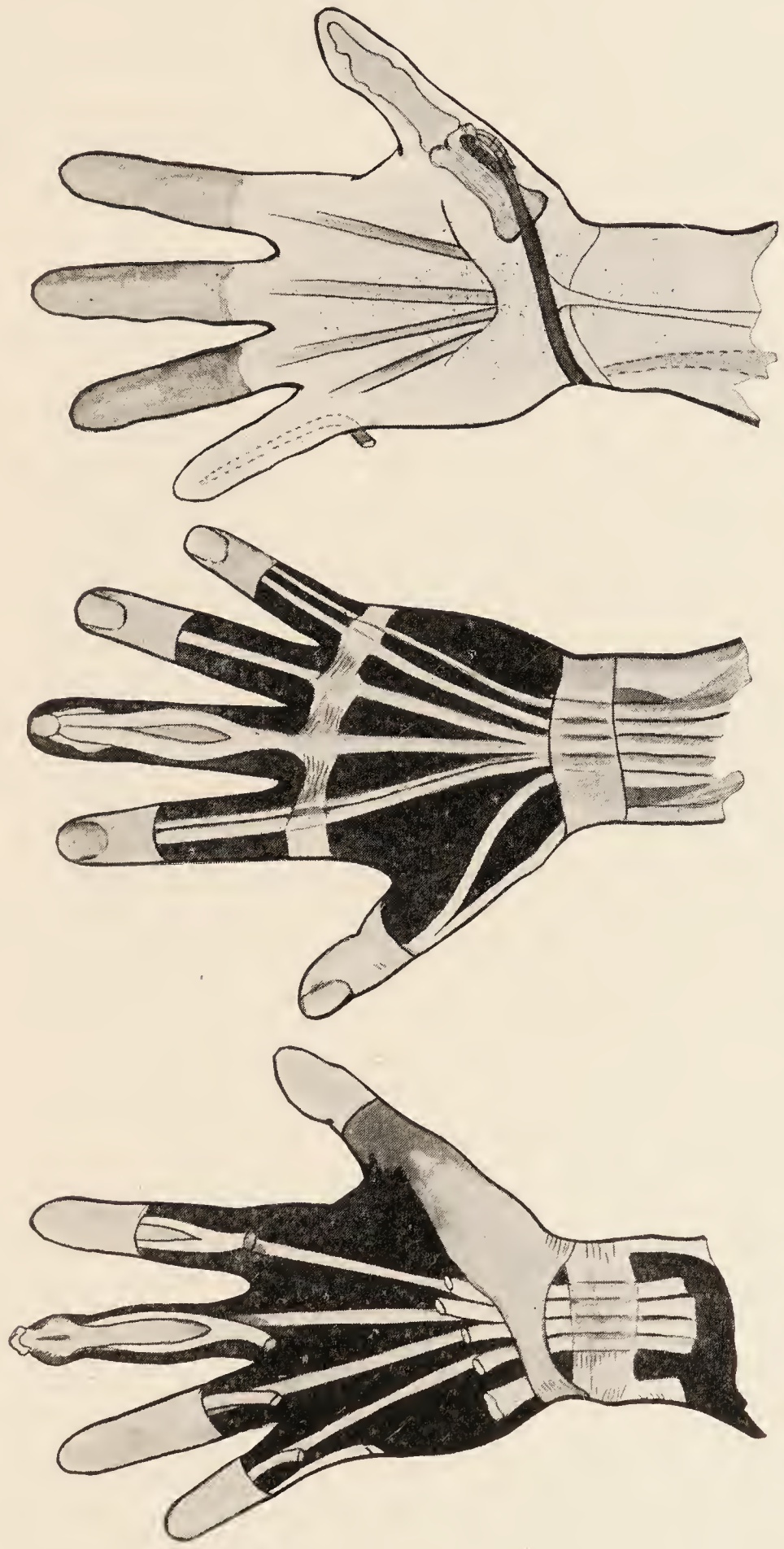


FIG. 562.

FIG. 563.

FIG. 564.

FIG. 562.—Diagrammatic drawing of the tendons of the hand showing the sublimis tendons cut across and removed from the palm and the profundus tendons exposed.

FIG. 563.—Diagrammatic drawing of the back of the hand and showing that there are normally two extensor tendons attached to the first, second, and fifth fingers.

FIG. 564.—Cook's method of utilizing extensor tendon of little finger to effect flexion and adduction of thumb.

joint from underaction or elongation of the flexor longus pollicis. This recurrence had persisted for about two years and with each attack, which upon application for treatment was of daily occurrence and followed by pain and aching up the arm. It was a painful manifestation of what is usually called a "double-jointed stunt" in boys and a source of gratification to the performer

and envy to his playmates. This patient, however, had the condition only in the thumb and it was a source of extreme discomfort to her, interfering with her daily ordinary and routine pursuits and piano lessons. It was not possible to trace any given traumatism in endeavoring to establish its etiology. Being the right thumb added to her difficulties, as she was normally right handed and called upon to use it more than the left. Months of so-called conservative treatment with adhesive strapping, leather appliances with elastic bands to permit flexion from 30° to full flexion but to prevent any extension whatever, failed to afford a shortening up of the flexors to prevent recurrence and relief. An elliptical incision was made so that the flexor longus pollicis came to lie under the centre of the flap and in the transverse plane of the metacarpopha-

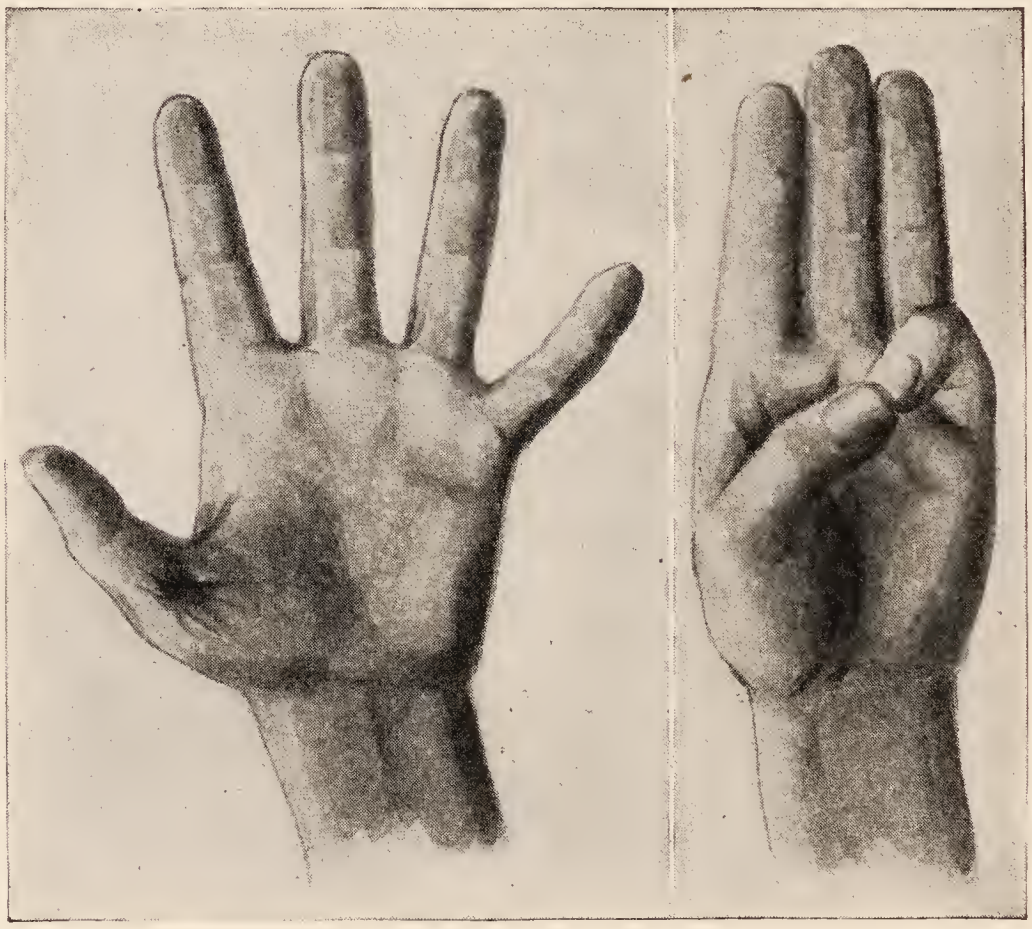


FIG. 565. FIG. 566.

FIG. 565.—Patient unable to flex the adductors of the thumb before operation.
FIG. 566.—Same patient after the Cook operation.

langeal joint of the right thumb; the tendon sheath and radial bursa were opened and the tendon grasped by the tendon holders placed ½ an inch apart. To prevent drying out, bits of absorbent cotton moistened with salt solution were placed beside the exposed area. The intervening tendon was then cut transversely across with a sharp scalpel at the adjacent margin of each tendon clamp, thereby shortening the tendon by ½ an inch. Buried sutures were inserted in the manner above described and by flexing the thumb, close approximation end-to-end with buried knots was obtained, when the sutures were tied. A small sheet of fat and fascia was dissected free from the inside of the skin flap and placed around the point of union. The edges of the sheath of radial bursa were restored to their proper position, but not sutured. The skin was sutured with fine interrupted silk sutures. Silver foil and tissue paper covered the incision and a gauze handkerchief was placed under the thumb and in the palm, and over

suitable dressing, adhesive plaster and a snug plaster of paris bandage held the thumb flexed. On the eighth day the skin sutures were removed, as the



FIG. 567.—Diagrammatic representation of the condition shown in Fig. 560 and transferring the sublimis tendon of the third finger to the profundus of the index finger.

skin wound was found entirely healed and the dressings re-applied to hold the thumb in the flexed position, which was maintained for four weeks, when after a



FIG. 568.—Roentgenogram of patient with severed flexor tendons of the index finger and partial destruction of the metacarpophalangeal joint.

brief course of massage and resistive exercises in flexion full function was established and no recurrence of the disability has returned.

Case 2. A soldier, who had been shot through the left hand in the cleft between the thumb and the index finger, was operated on by Robert J. Cook, formerly of my service, by the very ingenious method devised by him, as this man could not produce the opponens power in the thumb, which was held in extreme extension and abduction. Doctor Cook utilized the extensor minimi digiti, which he freed at the first phalanx of the fifth finger through a small incision and through a second incision above the styloid process of the ulna on the dorsum of the wrist located this tendon, drew it out of its sheath, passed it through the subcutaneous fat around to the palmar side to an anterolateral incision on the distal end of the metacarpal bone of the thumb, through which

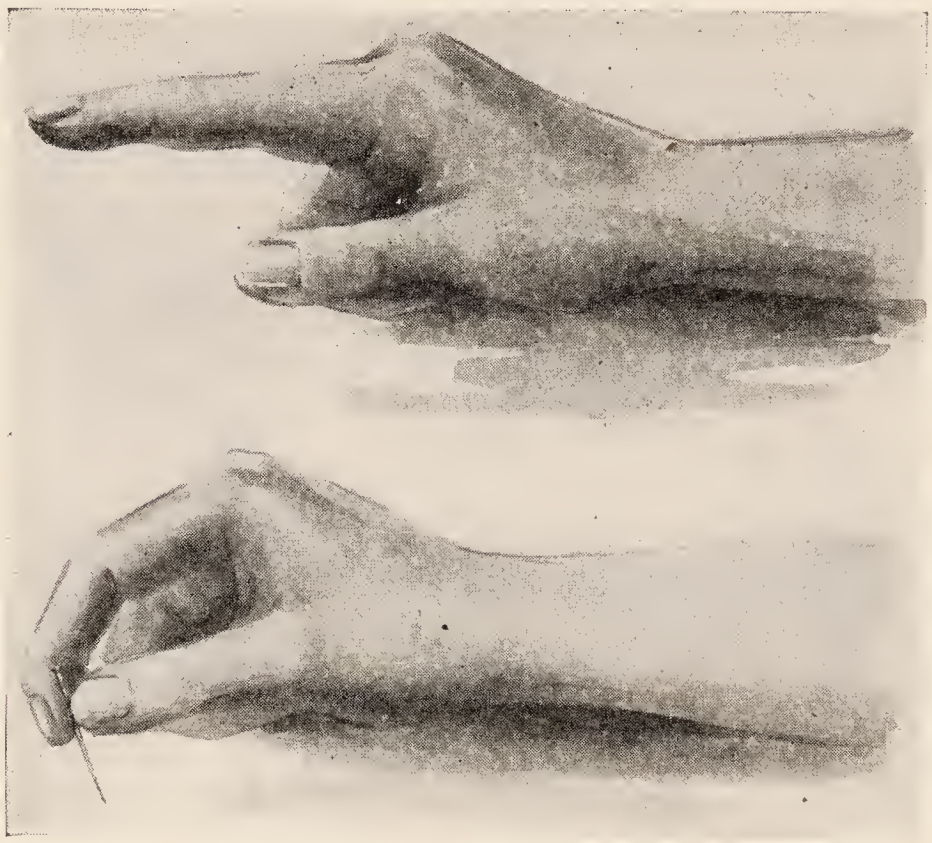


Fig. 569.—Condition of this patient before operation.
Fig. 570.—The power of picking up small objects after operation.

he passed the tendon and sutured it to itself under tension as shown in the diagram, while the thumb was held in the opponens position. The three incisions were closed and the fixation and after-treatment were similar to that used in Case 1. The man made an uninterrupted recovery of function, as shown in Figs. 564, 565 and 566.

Case 3. A soldier had been shot through the right index finger at the proximal end of the first phalanx, as shown in the X-ray and at the same time both flexor tendons were severed and their proximal ends were bound down by scar tissue in the thenal space, but the stump of the profundus at the first phalanx was identified and freed. After rounding off the jagged end of the phalanx and interposing free fat and fascia in the joint, the sublimis tendon of the middle finger was sutured end-to-end with the profundus distally. This case had complete restoration of flexor function so minute as to permit picking up a pin, as shown in Figs. 567, 568, 569 and 570.

Case 4. A soldier had been hit by a piece of shrapnel in the palm of the right hand, severing the profundus tendon of the middle finger, both flexors of the ring finger and also shattering the first interphalangeal joint of the middle finger,

so that this patient could not make a fist nor grasp a rod. The articulation was restored as in the preceding case and the sublimis tendon of the index finger



FIG. 571.—Roentgenogram of patient showing destruction of first interphalangeal joint of the third finger.



FIG. 572.—Diagrammatic representation of the destruction of the profundus tendons in both the third and the fourth fingers, also the destruction of the sublimis in the fourth, being the condition accompanying the joint destruction shown in Fig. 571. There is also shown the transferring of the sublimis of the second to the profundus of the third and the sublimis tendon of the third to the profundus tendon of the fourth.

given to the profundus of the middle finger and the sublimis of the middle finger given to the profundus of the ring finger (Figs. 571, 572 and 573).

As a result of these procedures, this patient was restored as shown in Fig. 573 before operation and after operation.

Case 5. Patient was shot through the palm of the hand, the tendons escaping, but the middle third of the third metacarpal was shot away and union

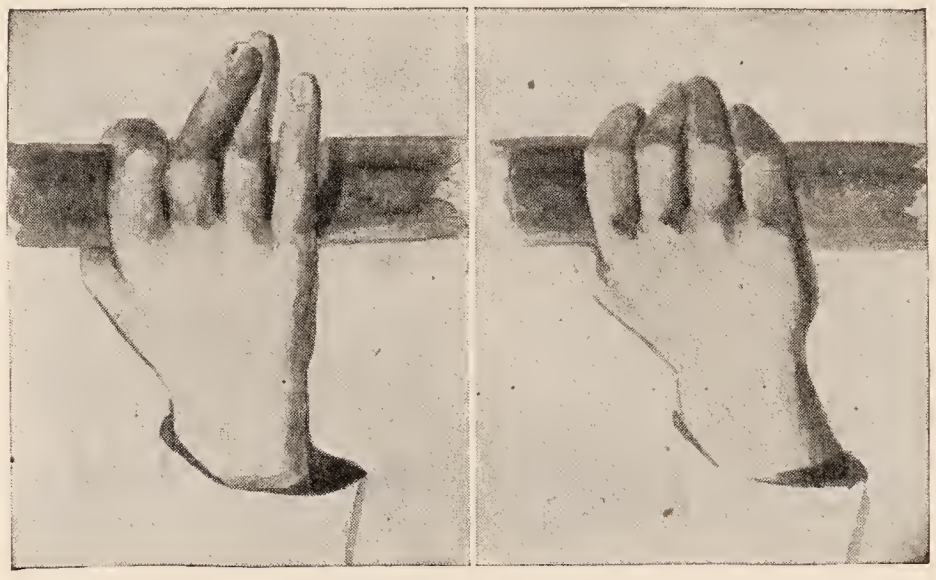


Fig. 573.—At left, condition of this patient before operation, unable to grasp objects. At right, the grasp restored after operation.

had not occurred and the hand was very weak(Figs. 574 and 575). Sufficient bone was left in the distal fragment to permit securing of a *sliding bone-graft*, which was done with satisfactory results.



Fig. 574.—Roentgenogram shows the patient with destruction and non-union of third metacarpal.

Case 6. This patient was shot also through the palm of the hand at the junction of the middle and distal end of the third metacarpal bone without much loss of substance but with no tendency to union and with much loss of



FIG. 575.—Roentgenogram shows sliding bone-graft obtained from distal segment to restore bone continuity. (Case 5.)



FIG. 576.—Roentgenogram shows non-union of third metacarpal. (Case 6.)

power in the grasp. The tendons were not affected except so far as the mechanics of the hand lessened their efficiency (Figs. 576 and 577). A small bit of bone was removed from the tibia and an *autogenous inlay and spike-graft* was



FIG. 577.—Autogenous bone-graft obtained from the tibia shown. (Case 6.)

put in the proximal and distal fragments respectively, with union and restoration of power and function.

CASE 7. A girl, seven years old, was sent to the corner store in mid-winter to get a can of gasoline. On her way home, she stumped her toe and spattered a



FIG. 578.—Roentgenogram showing destruction of portion of ulna and soft parts, with bone-graft (tibia) *in situ*.

large quantity of gasoline over her dress. On reaching home, she went to the kitchen range to warm herself, as she was chilled from the low temperature outside and the evaporating gasoline. Immediately her dress was in flames and she was deeply burned on the left hand, arm, left side of face and ear. On

admission, dense scar formation permitted only slight movement at the axilla, elbow held flexed 110°, and the hand was a typical *main en griffe* with flexed wrist and fingers, the tips of several of the latter having sloughed off. After removing the scar, a pedicle whole thickness flap from the back restored the skin



FIG. 579 (Above).—Skin flap obtained from abdomen (whole thickness). (Below) Arm prior to skin grafting.

of the axilla and by means later, of a sliding flap, the elbow was restored. Finally, by means of a whole thickness skin graft, skin was obtained from the abdominal wall and a new palm and palmar surface of the wrist-joint was made leaving the pedicle attached to the abdomen two weeks. This was then cut



FIG. 580.—Whirlpool arm bath.

away and the remaining sutures applied with restoration of function at the wrist joint. Subsequently massage and a "cock-up" splint produced a much more presentable and useful hand.

Case 8. This patient was shot through the lower third to the ulna, carrying a large part of the bone, tendons, and skin away, as is shown in Figs. 578 and 579. This had to be restored in the order of skin, bone, and tendons, which was accomplished as shown in the illustrations.

The above cases represent the types most commonly met with.

After-Treatment.

Many of these cases show marked stiffness after anatomic or functional restoration and require more or less prolonged after-care and attention to

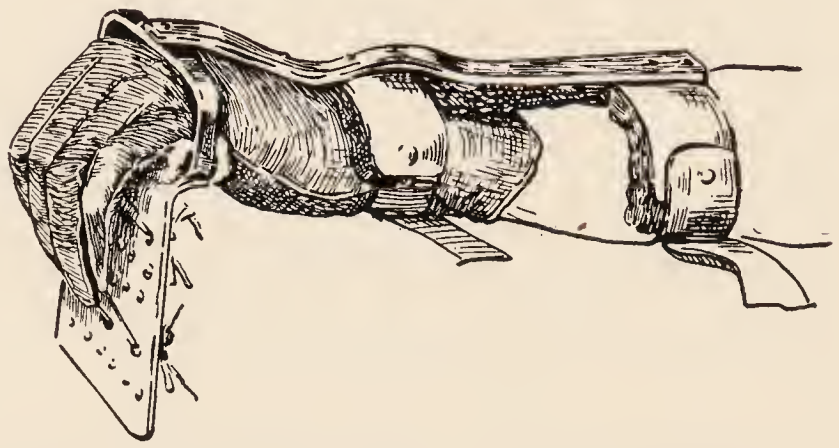


Fig. 581.—Skirball's splint. Palmar application.

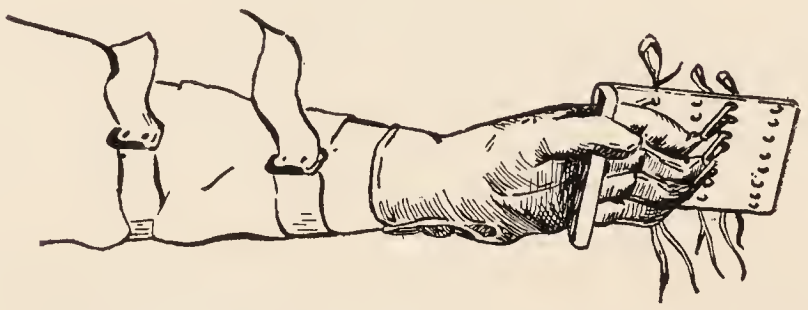


Fig. 582.—Skirball's splint. Dorsal application.

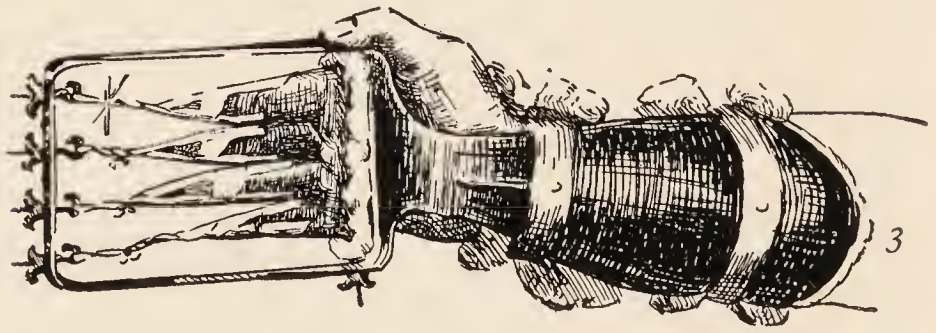


Fig. 583.—Lewis splint.

secure the maximum efficiency obtainable. Much of the success secured in these cases should be attributed to the physiotherapist as well as to the surgeon. The use of hydrotherapy in the warm or hot "whirl-pool" is an excellent preparation for manipulative treatment with progressively increasing passive, active, and resistive movements either in or out of the water, and later massage and Bristow surging faradism (Fig. 580).

Much stiffness is often found in old traumatic and paralytic hands with wrist drop and flexed fingers and those cases showing marked tightening up of the ligaments at the metacarpophalangeal joints so that in the interim between physiotherapeutic treatments the parts may be continually stretched and

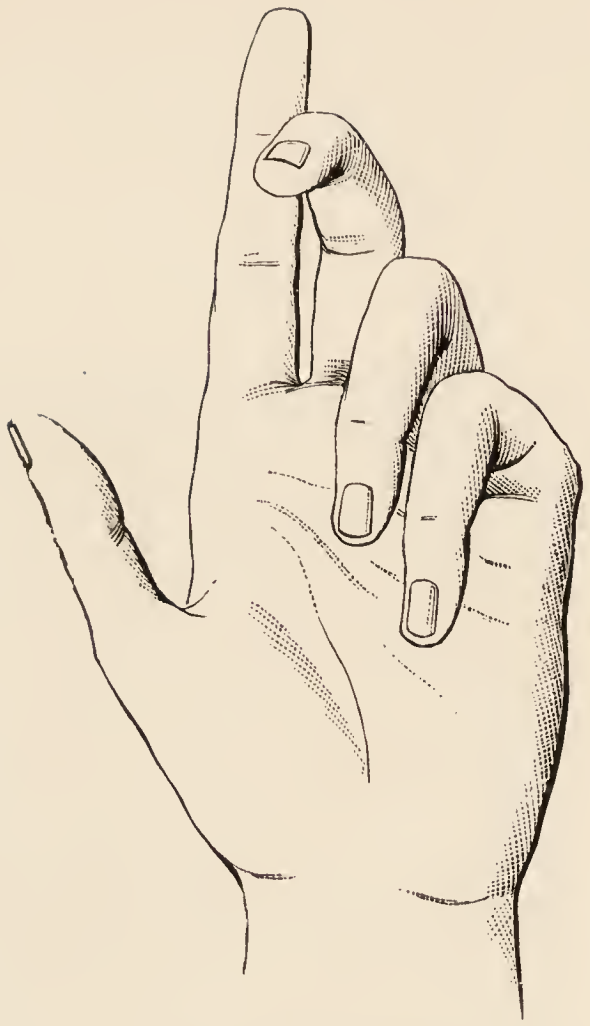


FIG. 584.—Dupuytren's finger contraction. (*Ashhurst.*)

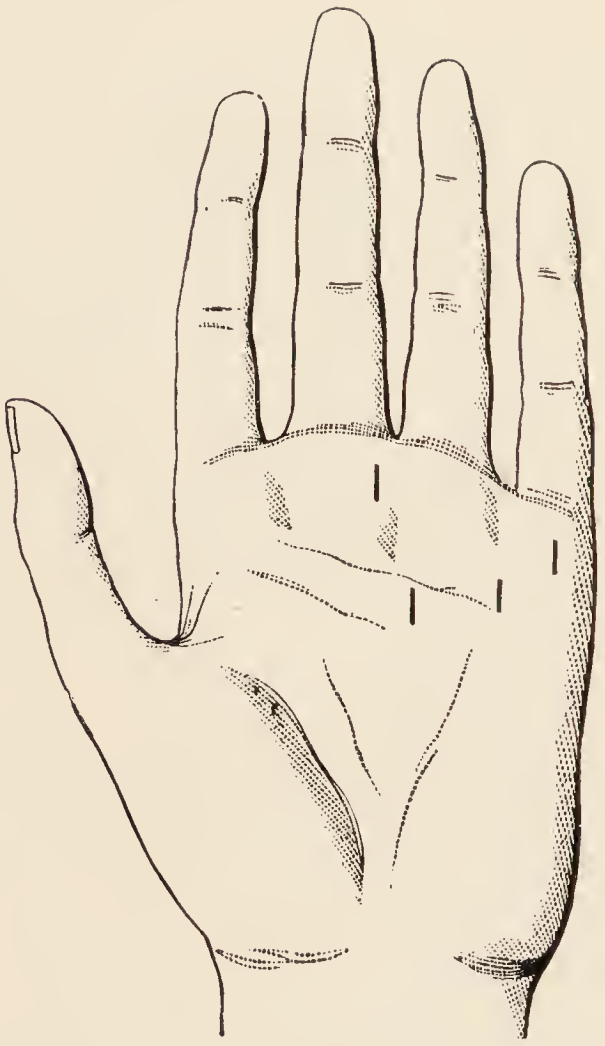


FIG. 585.—The same hand after operation. (*Ashhurst.*)



FIG. 586.—Dr. Frank Lynn's case of macrodactylism and hypertrophy of left pectoralis major.



FIG. 587.—Congenital hypertrophy of fingers. (*Morton.*)



FIG. 588.—Congenital hypertrophy of fingers. (*Jones.*)



FIG. 589.—Congenital hypertrophy of toes. (*Shoemaker.*)

recontracture prevented. This may be accomplished by suitable splints. I have found the Skirball and Lewis splints most useful.

The former was devised by Louis I. Skirball, of Boston, formerly of my service, and is made of aluminum and is very light in weight. It consists of a perforated square palmar or dorsal plate, a ring around and just below the metacarpophalangeal joint and bands at the carpus and upper forearm with straps, padded where necessary with felt. A heavy walking glove is placed on the hand



FIG. 590.—Intrauterine amputation of right leg and fingers of both hands.



FIG. 591.—Intrauterine cleft of right foot.

with strong tapes at the distal end of each phalanx of the glove on the palmar or dorsal aspect as the case may require so that these tapes may be passed through the perforations and tied as tightly as possible to maintain the correction. The perforated plate also may be bent in any desired form in the brace shop (Figs. 581 and 582).

The Lewis splint consists of the regulation "cock-up" palmar and forearm splint plus a movable rectangular quadrangle extending two to three inches beyond the finger tips. This quadrangle is attached to the "cock-up" just proximal to the heads of the metacarpal bones and fixed at any angle of flexion

that may be desired by two lateral thumb nuts. On each finger at fault is fastened surgeon's plaster adhesive traction straps terminating in tapes which are caught over hooks at the distal end of the quadrangle. Traction may be regulated by thumb nuts on the screw thread of the hooks whereby the stretching of the ligaments at the metacarpophalangeal joints may be effected (Fig. 583).



FIG. 592.—Single congenital absence of the tibia. (*Ehrich.*)



FIG. 593.—Congenital deficiency of femur. (*Young.*)

The type of case which offers the most serious difficulties to the restoration of manual dexterity is that involving the tendons at the wrist binding them down and massing them, as an extensive scar, which in all instances cannot be appreciated as to extent by what appears on the surface, because the primary infection involves not only the tendon sheaths but extends subcutaneously in all directions that are anatomically possible, so as to cause adhesive agglutination



FIG. 594.—Congenital deficiency of extremities. Sitting position. (*Shoemaker.*)



FIG. 595.—Congenital deficiency of extremities. Position assumed when walking on hands. (*Young.*)

of the fascial spaces and bursae as well; added to this the fusion of the carpal bones by impaction plus an inflammatory process renders the wrist joint and tendons immobile and ankylosed, so that little can be done to aid such cases if extensive as shown by the X-ray and unyielding under an anaesthetic and later to physiotherapy.

Finally, arthrodesis, if extensive between the radius and ulna, preventing pronation and supination, hampering the proper use of the hand, is a difficult

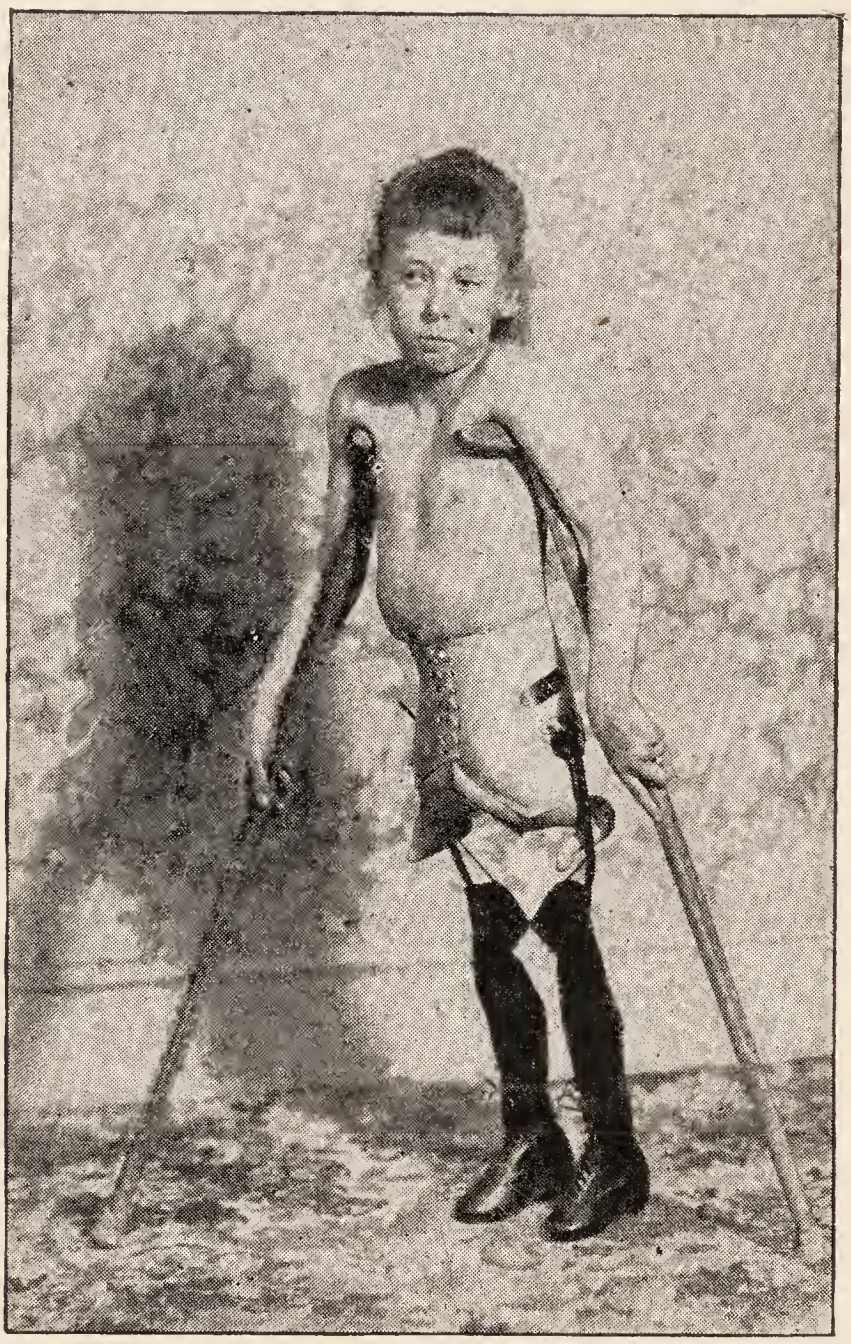


FIG. 596.—Congenital deficiency of extremities. Permanent apparatus applied. (*Young.*)

complication to combat because by the operative chiseling away of the union and the implantation of fat and fascia or muscle, one can rarely be sure of curative results, for in spite of all we do, the bridge of bone will more often than not re-form.

Dupuytren's Contraction.

This condition consists of contracture of the palmar fascia. It occurs more often in old men and may be bilateral. It is probably traumatic in origin, associated with the use of tools, canes, etc., and in those of a gouty or rheumatic diathesis. It is not accompanied by shortening of the flexor tendons, as the fingers can be passively fully extended, but voluntary active extension especially on the ulnar side is limited by the *tight fascia*. Operative treatment alone affords relief and consists of dissection out of the palmar fascia, under a curved

flap incision, with the curve distally. Fat and fascia should be interposed before suturing (Figs. 584 and 585).

Madelung's Deformity.

This is usually a progressive forward displacement or dislocation of the hand at the radio-carpal joint, due to retarded growth of the radial epiphysis or relaxation of tendons. It occurs in girls at adolescence in 80 per cent. of the cases

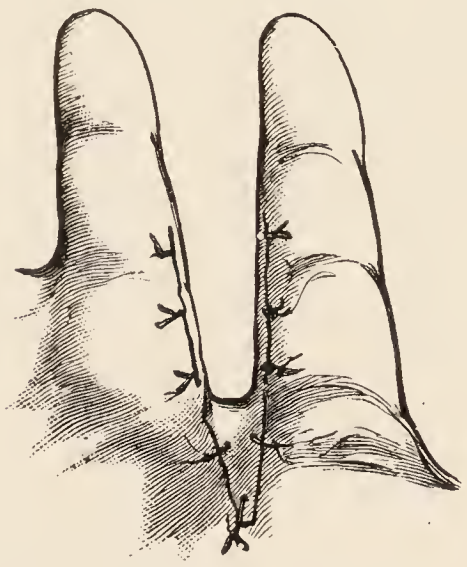


FIG. 597.—Velpeau operation. Dorsal flap brought through between fingers and stitched on the palmar side; also wound closed on opposite side of fingers. (*Agnew.*)

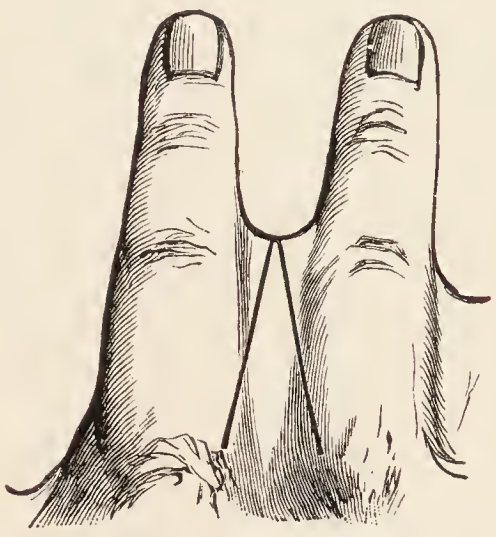


FIG. 598.—Form of incision for webbed fingers in Velpeau operation. (*Agnew.*)

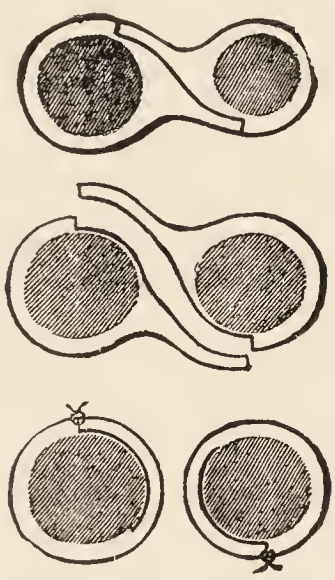


FIG. 599.—Didot's operation for syndactylism, represented in cross-section. (*Bradford and Lovett.*)

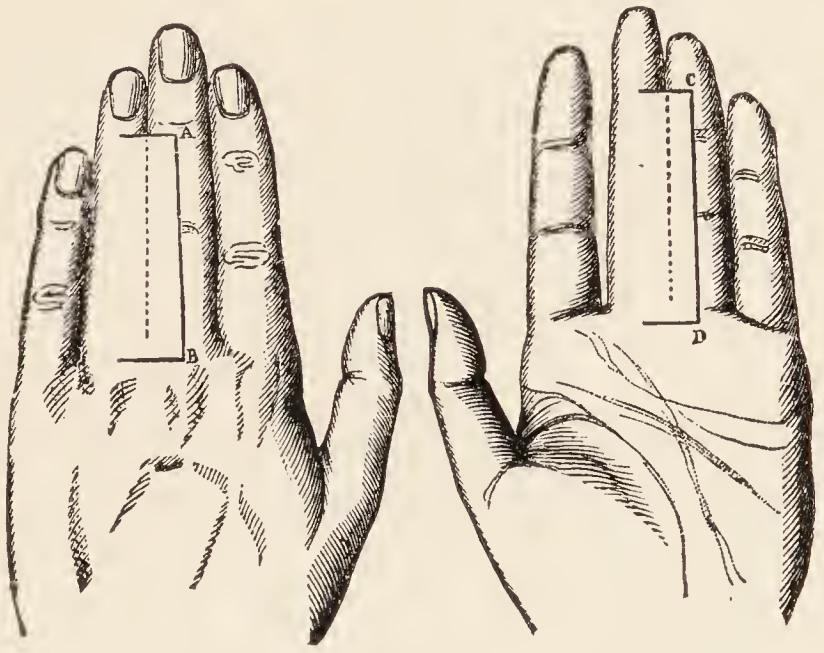


FIG. 600.—Didot's operation for syndactylism. *A*, *B*, Dorsal flap; *C*, *D*, palmar flap. (*Bradford and Lovett.*)

seen. The ulna is unduly prominent and the hand is deviated to the radial side, as a rule. A leather or plaster of paris wrist band and hand support may be worn in the early cases and tenotomy or osteotomy may be required later to equalize the length of the bones of the forearm.

Club Hand.

This condition is more often found with some bone deficiency usually of the radius and a bone grafting operation is required to give support on the radial side from the ulna. Cases of simple contracture may be stretched and massaged and held by a plaster splint.

Polydactylism.

Supernumerary fingers or toes are occasionally seen and as they are rudimentary and in the way, are best amputated. At times, the thumb is bifed

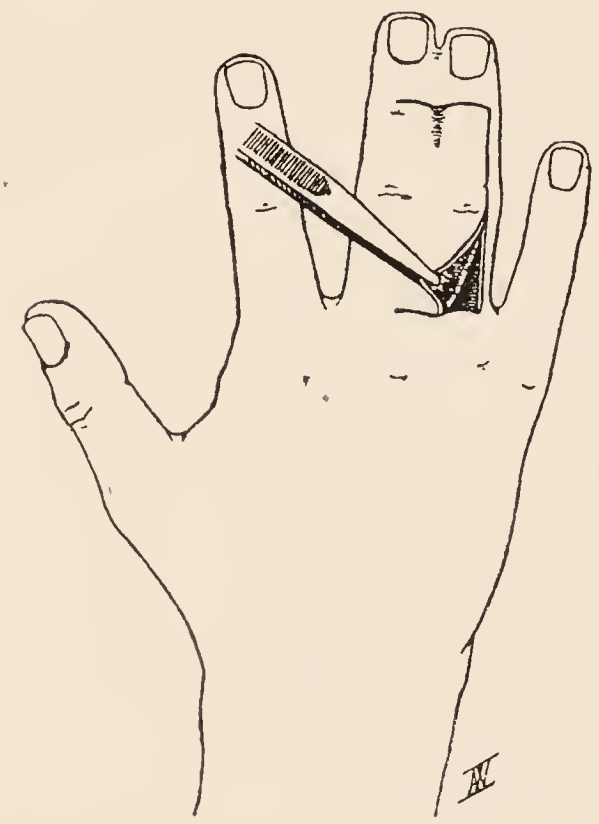


FIG. 601.—Dissection of the dorsal strip of skin. Operation of Forgue for webbed fingers. (*Young.*)

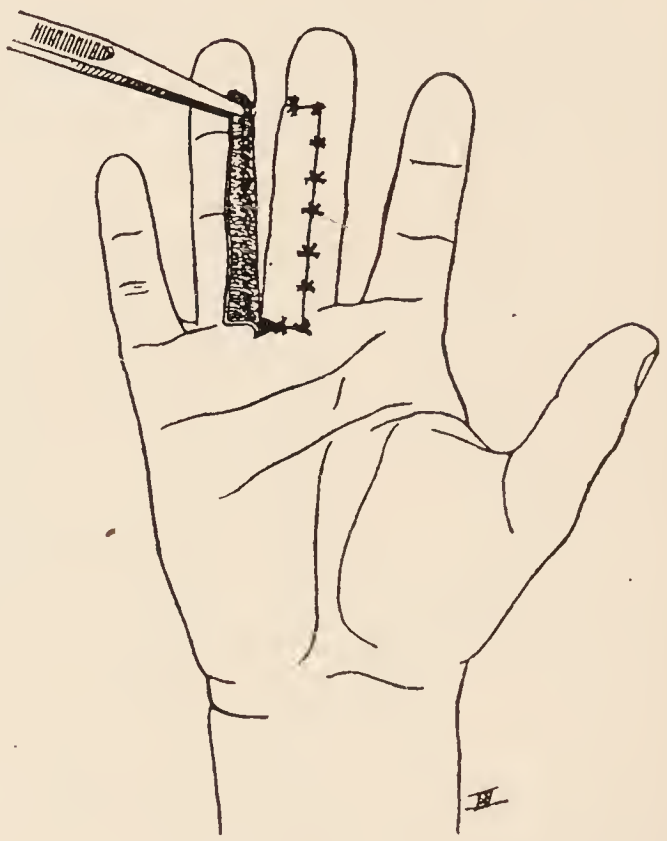


FIG. 602.—Application of the dorsal strip to the internal and palmar surfaces of the middle finger. (*Young.*)

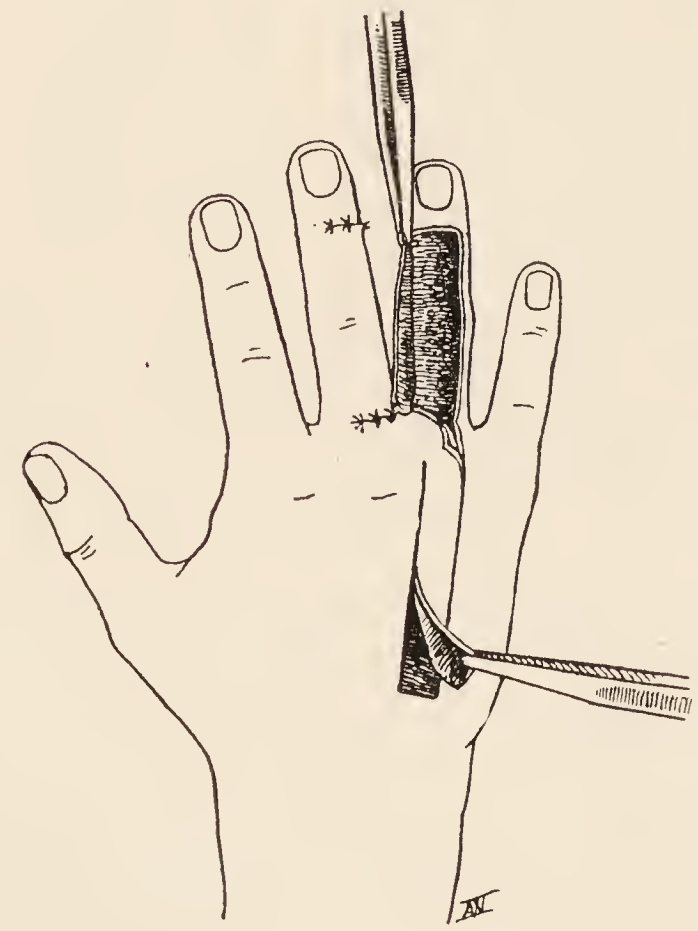


FIG. 603.—Dissection of a strip to re-cover the external and dorsal surfaces of the third finger. Forgue operation for syndactylism. (*Young.*)

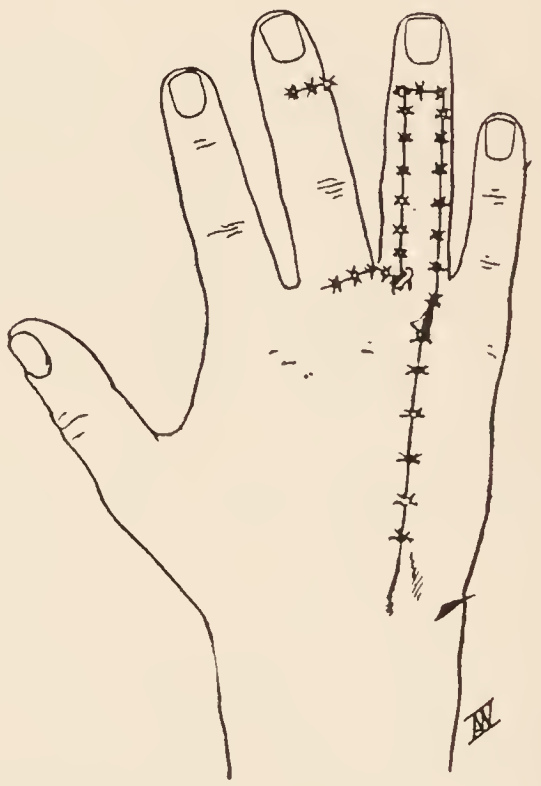


FIG. 604.—Result of the operation (*Young.*)

and fused, so that it is best left alone. More often we see a sixth finger next to the little finger.

Macrodactylism or Congenital Hypertrophy.

One or more fingers or toes or the entire hand are occasionally seen enormously hypertrophied and may require plastic reduction or amputation (Figs. 586, 587, 588 and 589).

Ectrodactylism.

Intrauterine amputation, absence of certain fingers or toes, constriction, clefts and deformation are not rare. But little can be done to help such cases (Figs. 590, 591, 592, 593, 594, 595 and 596).

Webbed-fingers or Syndactylism.

This also is not a rare condition and is remedied by a median incision on the palmar side of one finger and a dorsal incision on the adjacent finger forming the web. Transverse incisions are carried to the top and bottom of the web and skin flaps thus made suffice to cover each finger separately when the web is thus freed (Figs. 597 to 604).

Mallet Finger.

Traumatism may cause tearing of an extensor tendon from the terminal phalanx, lead to "Mallet Finger" and require a tendon suture to the periosteum to overcome the flexion deformity.

Trigger Finger.

Old inflammatory thickening in the sheath or tendon may lead to a point of stricture in functionating and cause the finger to snap like a knife blade or cause a "Trigger Finger" or catching as the finger is moved. It is corrected by division of the constricted tendon sheath.

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